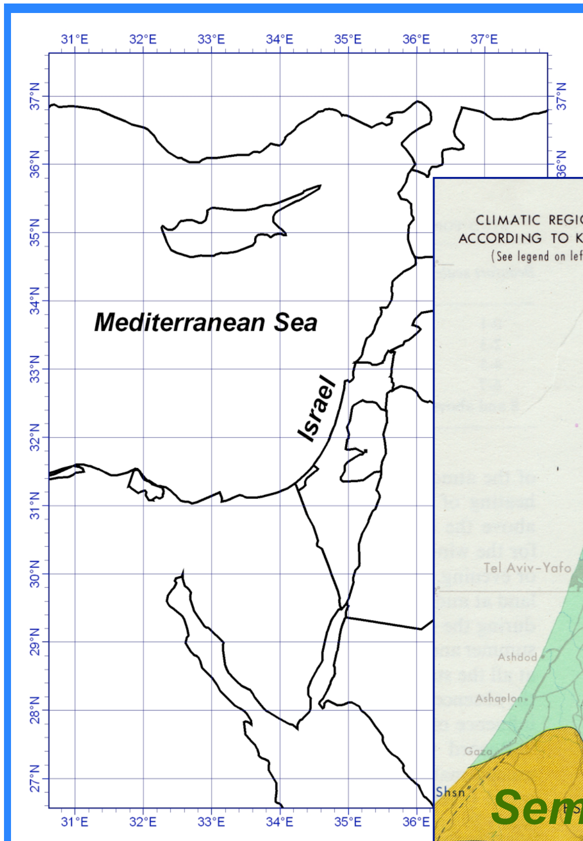
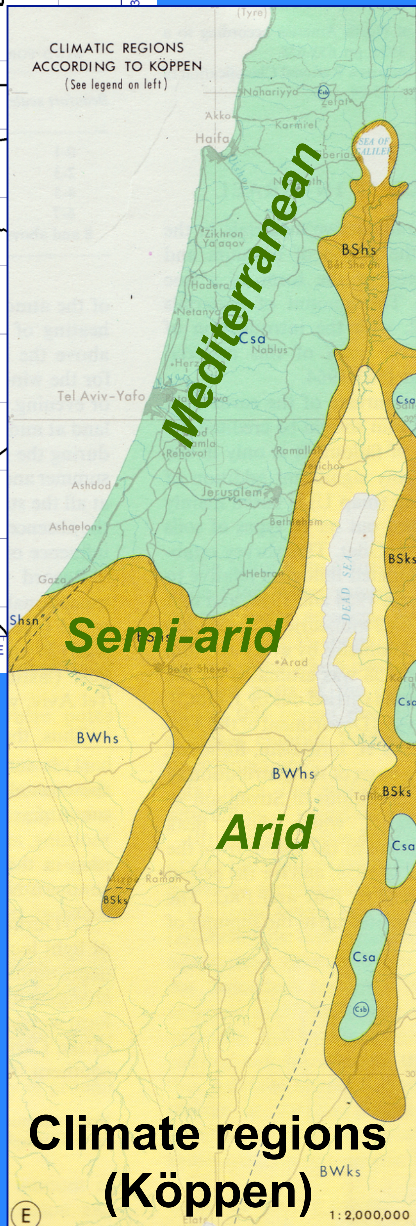
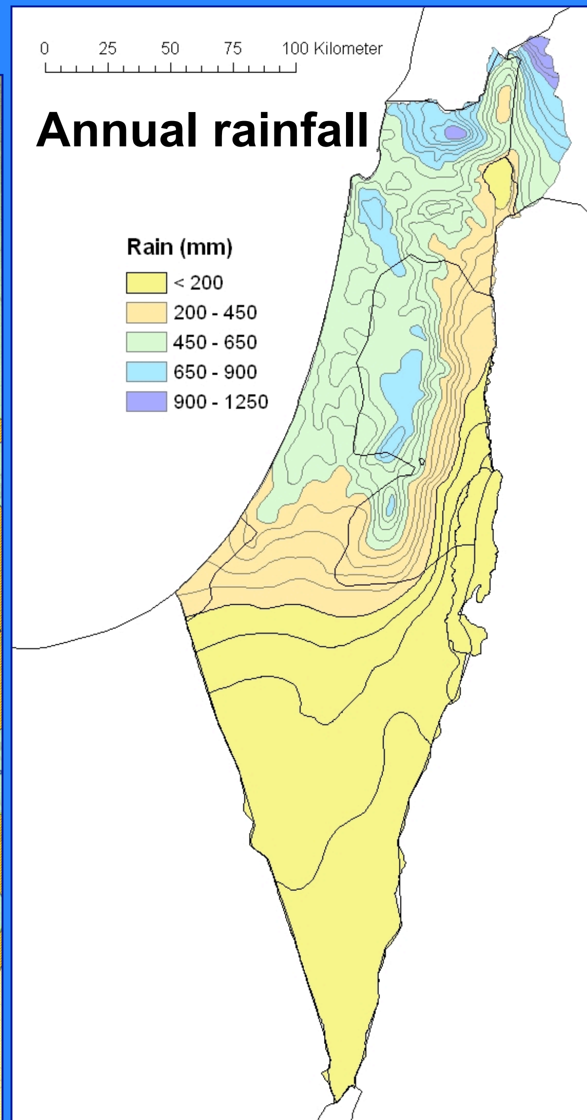
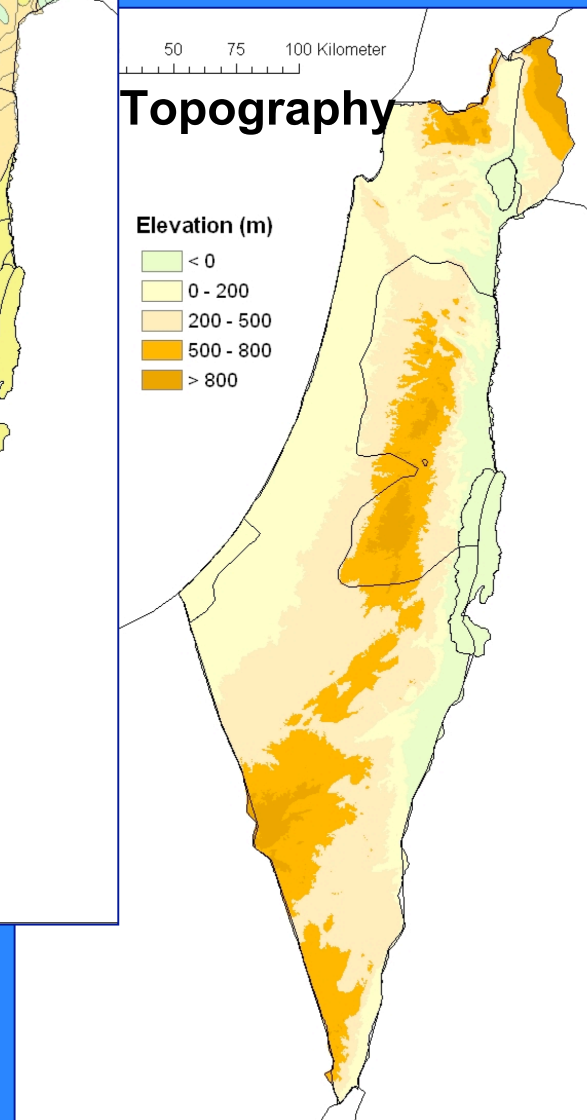
Israel



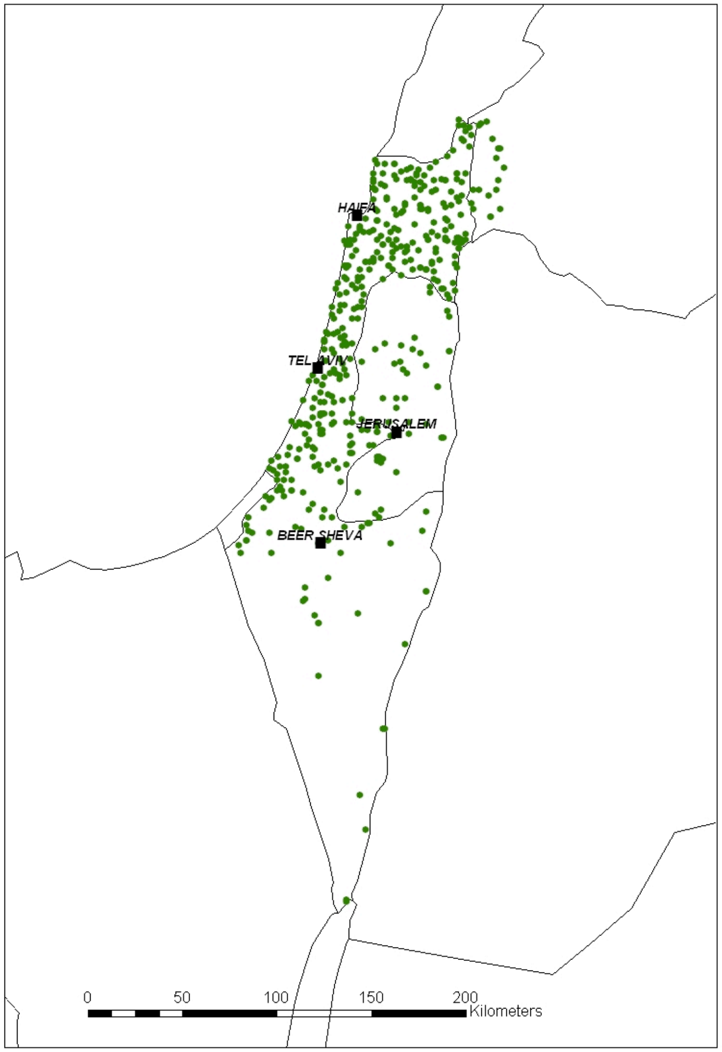


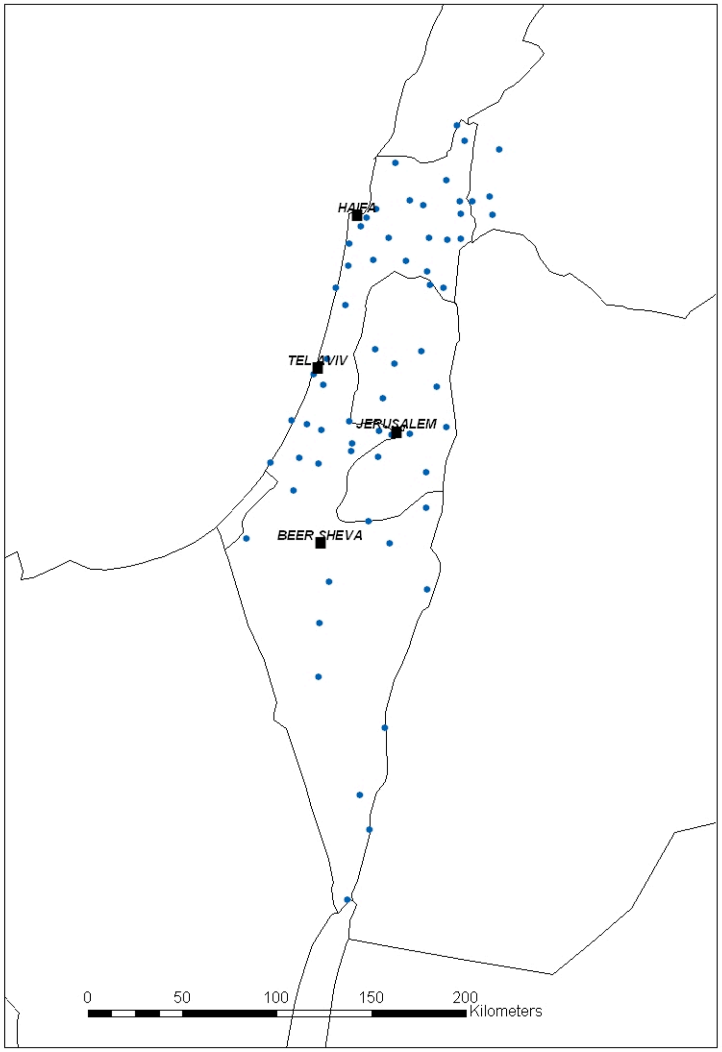




Efrat Morin
(HUJI)
&
Eyal Amitai
(NASA/GMU)

Daily and automatic gauge networks over Israel (Israel Meteorological Service – IMS - data)



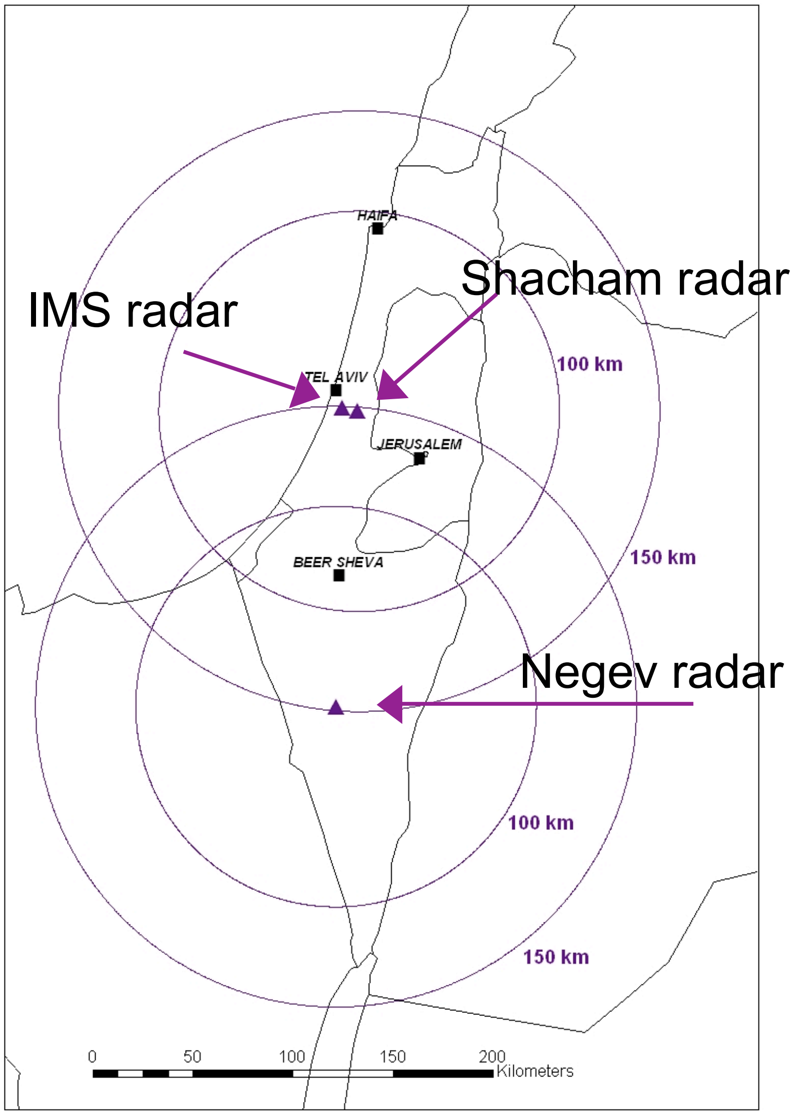


Daily rain gauges (~460)

Automatic (10 min) tipping bucket rain gauges (~65)

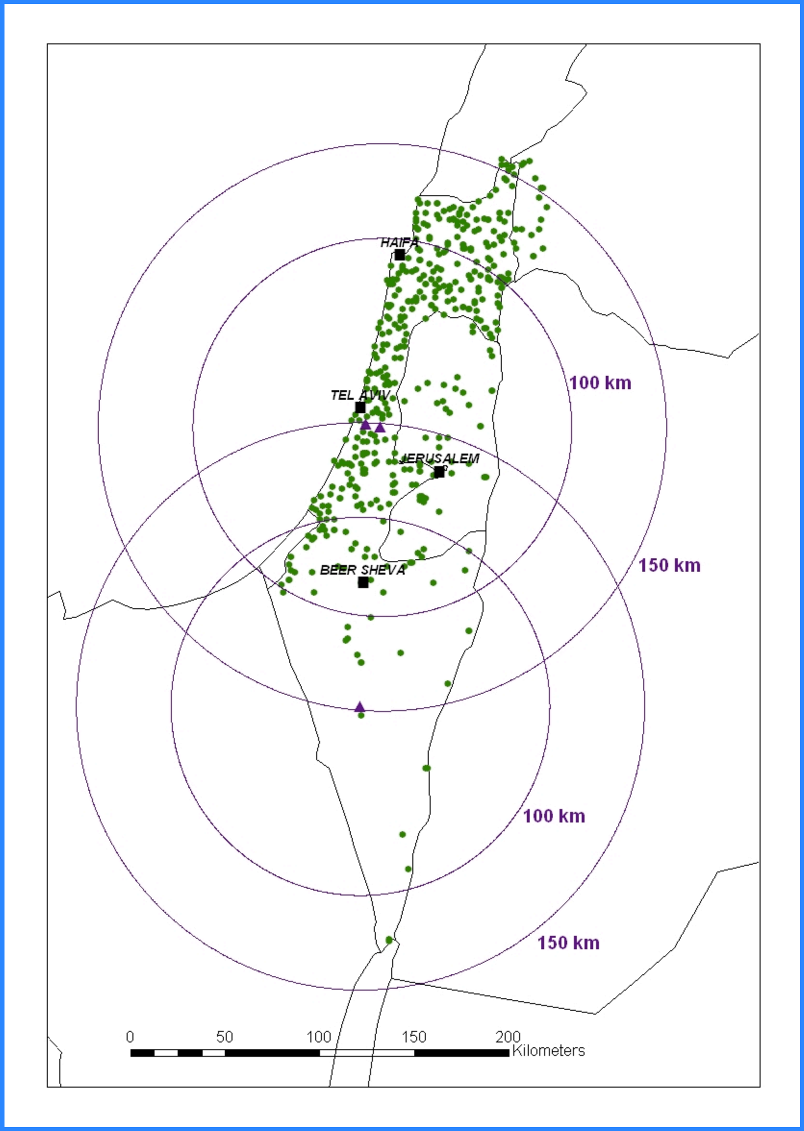
Obtained from the Israel Meteorological Service

Ground Meteorological Radar Systems in Israel

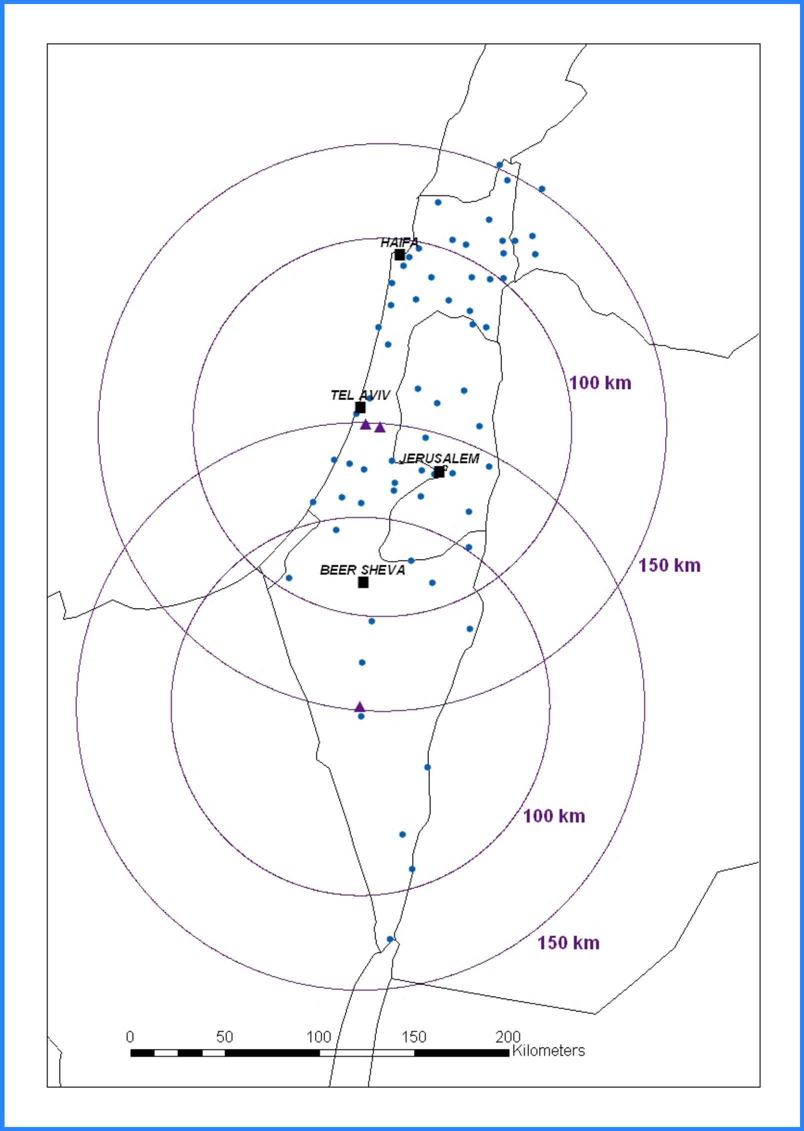


	IMS	Shacham	Negev
Wave length	C-band	C-band	C-band
Beam width	1.0º	1.4º	1.0º
Bin width	0.5 km	1 km	0.25 km
Doppler	Yes	No	No
Data recorded	Yes	Yes	Yes
Real-time data	Yes (in principle)	Yes (in principle)	No

Rain gauges and radar coverage



Daily rain gauges



Automatic rain gauges

Example of application: QPE

Morin and Gabella, Radar-based Quantitative Precipitation Estimation over Mediterranean and dry Climate Regimes. *J. Geophys. Res. Atmosphere*, 2007

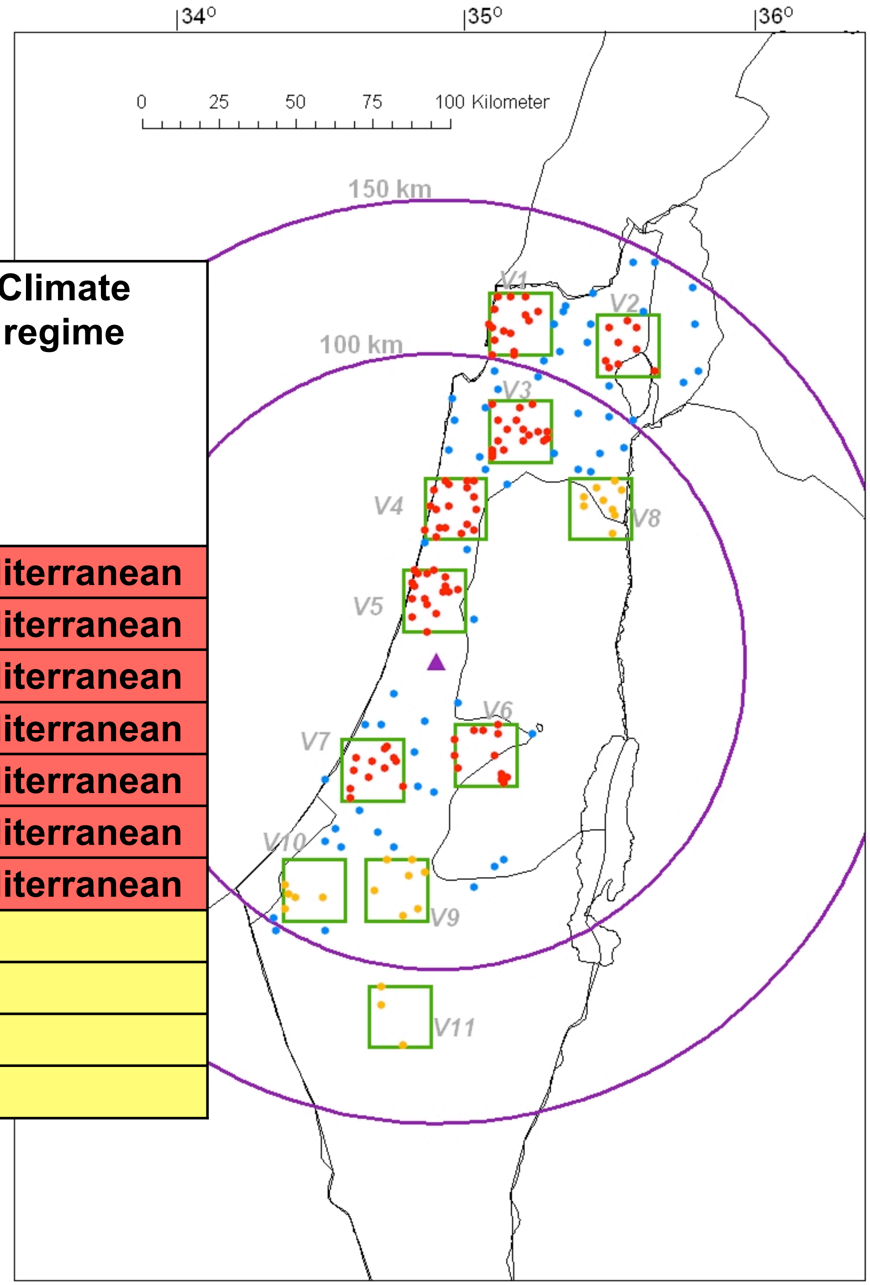
- Objective: QPE of rain depth
- 28 rainy periods (258 rainy days) during 1998-2003
- C-band radar system (Shacham)
- Ground-clutter and beam blockage QC procedures
- Daily rain gauge data (IMS) for training and validation
- 59 training gauges
- 123 gauges in 11 validation areas 20x20 km^2
- Gauge adjustment method: Weighted Multiply Regression (WMR).

* This research continues to estimate daily rain depth with several gauge-adjustments

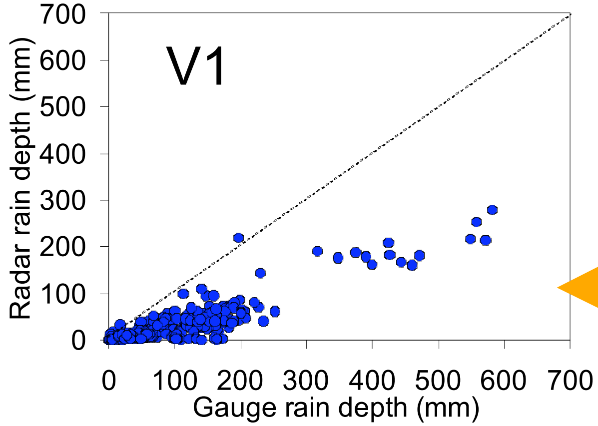
Example of application: QPE

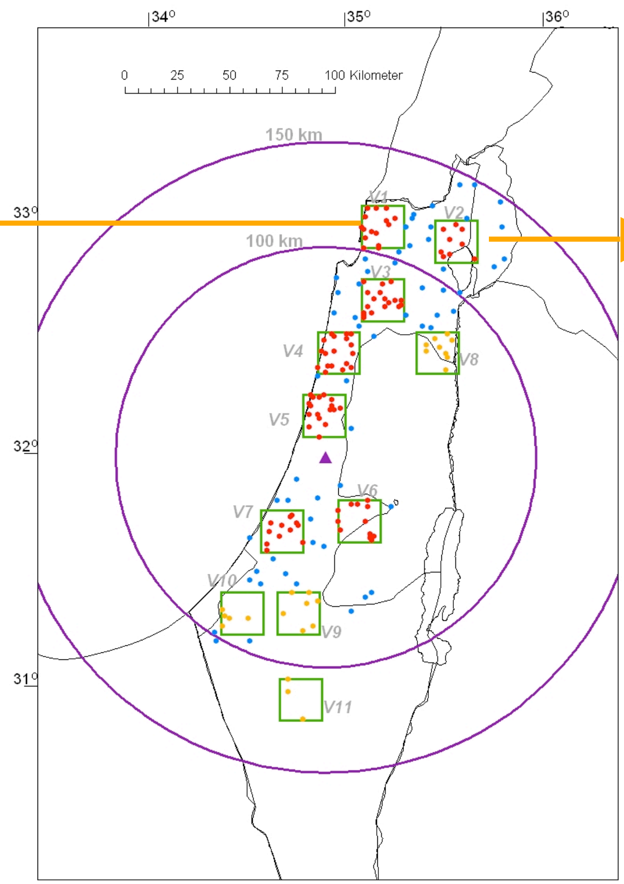
Validation areas

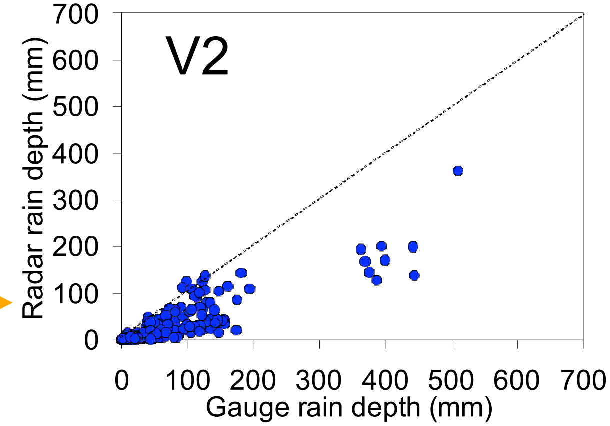
Label	Number of gauges	Mean distance from the radar (km)	Mean height of gauges (m)	Mean radar beam height (m)	Annual Rain (mm)	Climate regime
V1	15	112	128	2637	688	Mediterranean
V2	9	119	148	2918	546	Mediterranean
V3	18	79	120	2104	579	Mediterranean
V4	18	51	42	1574	595	Mediterranean
V5	17	23	49	1025	586	Mediterranean
V6	12	34	663	1881	549	Mediterranean
V7	12	40	71	1302	453	Mediterranean
V8	9	76	-36	2244	342	Dry
V9	7	73	288	2244	227	Dry
V10	5	89	105	2007	231	Dry
V11	3	115	357	2772	110	Dry



Example of application: QPE Fit for Mediterranean validation areas



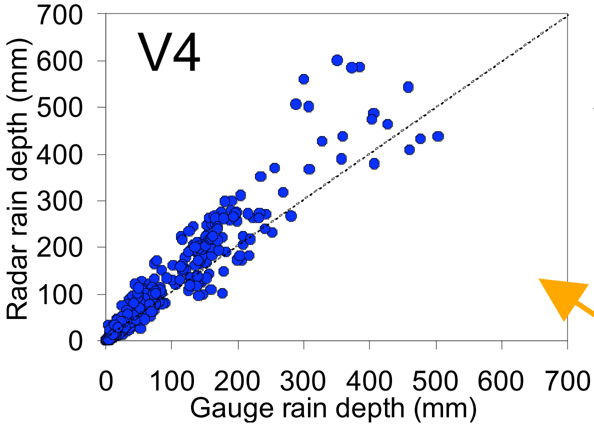




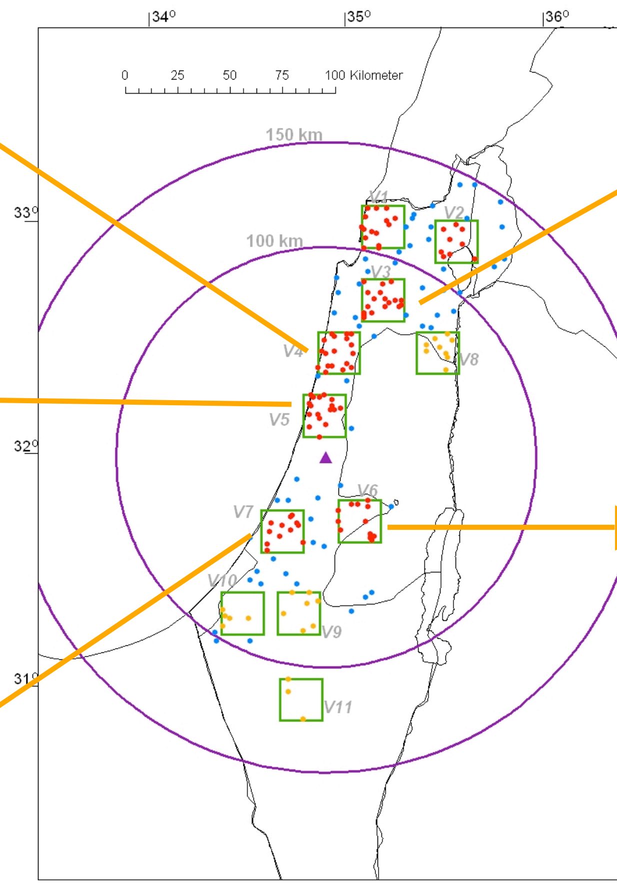
	Bias	FSE
V1	0.32	0.72
V2	0.44	0.61

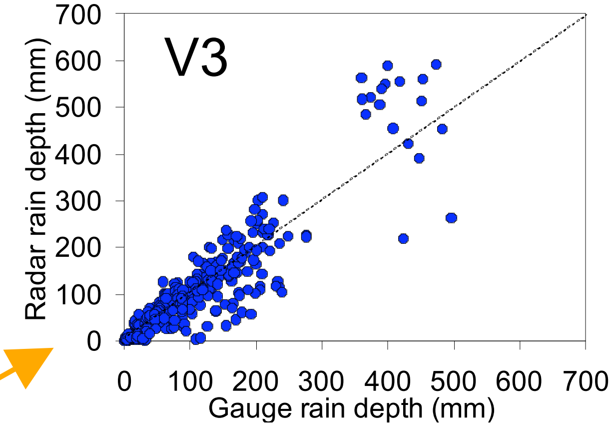
BAD FIT FOR THE TWO FAR NORTHERN VALIDATION AREAS!!!
DUE TO OVERSHOOTING (MORE THAN 100 KM DISTANCE).
BUT RELATIVELY GOOD FIT FOR THE OTHERS...

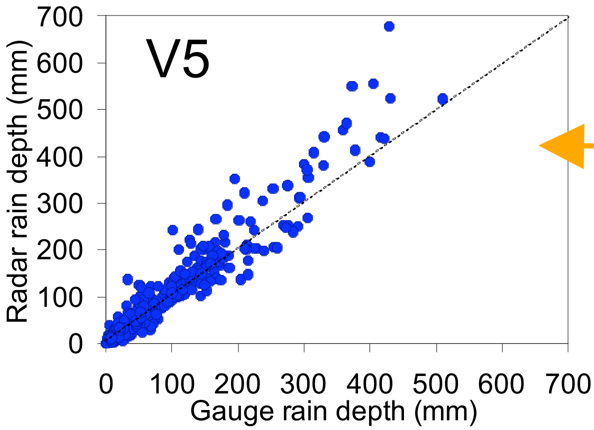
Example of application: QPE

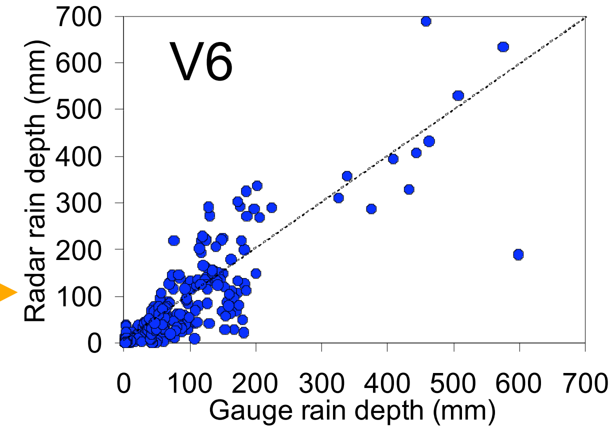


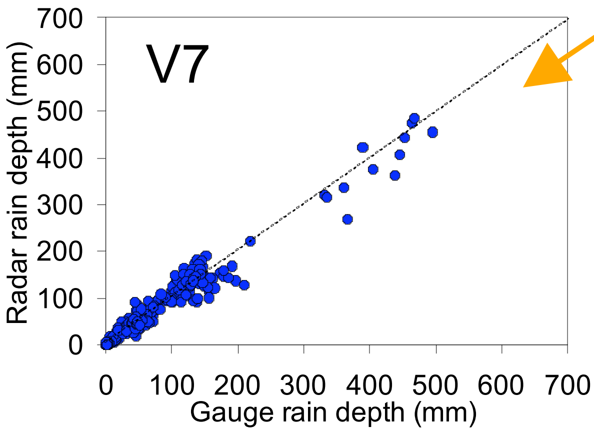
Fit for Mediterranean validation areas





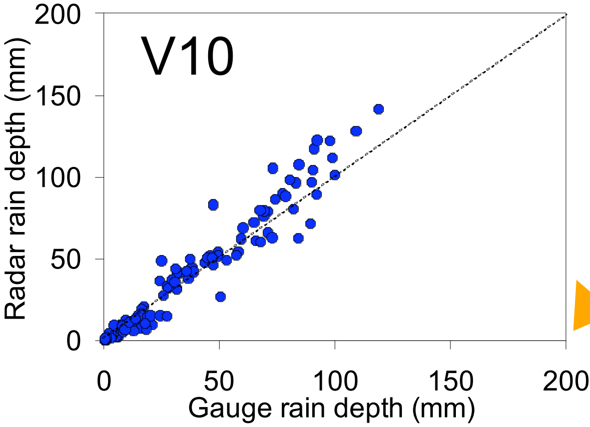


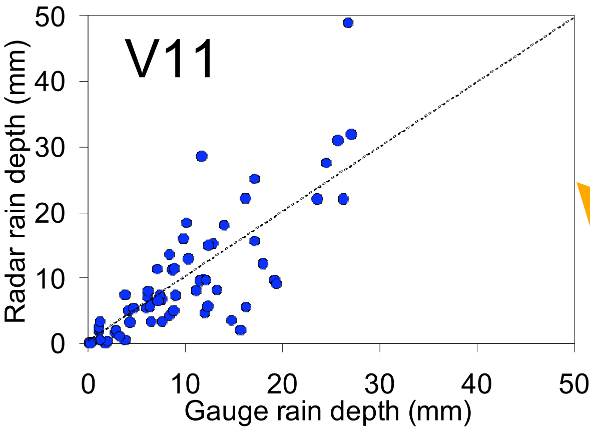


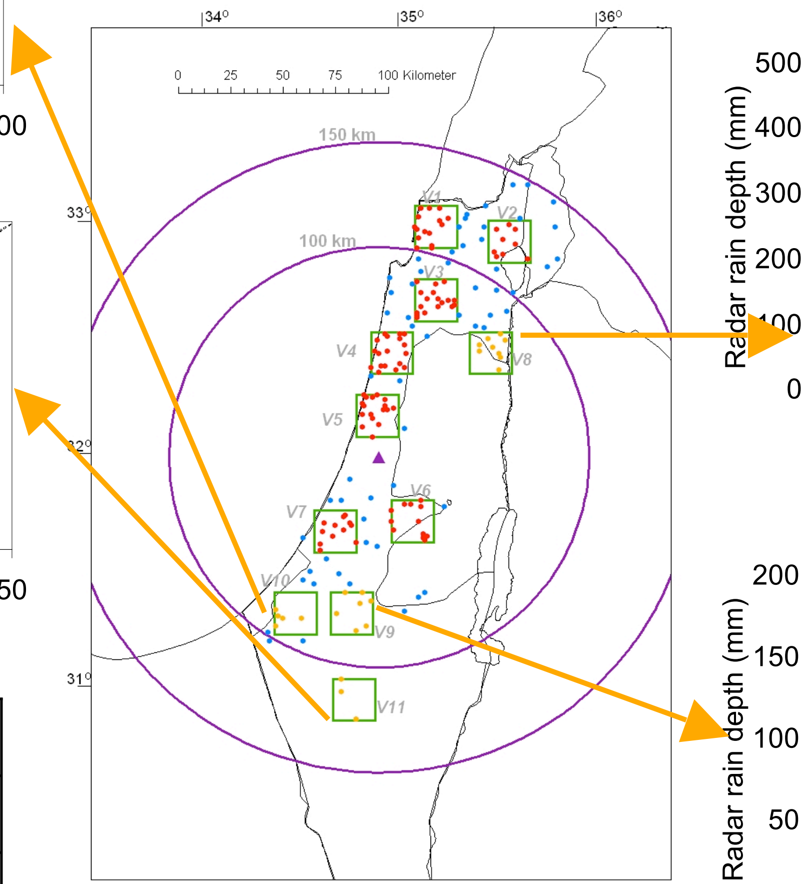


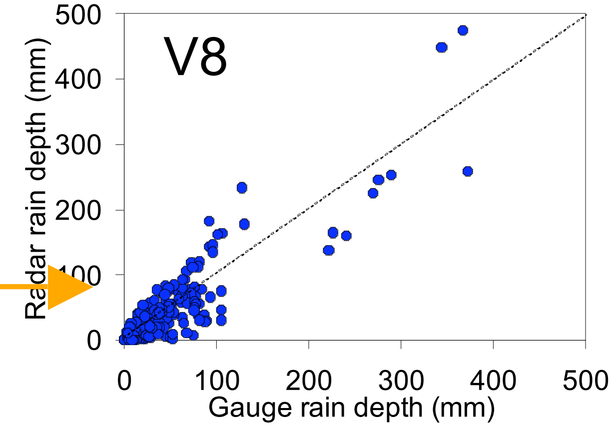
	Bias	**FSE**
V3	1.01	0.34
V4	1.30	0.41
V5	1.12	0.32
V6	0.93	0.49
V7	1.00	0.19

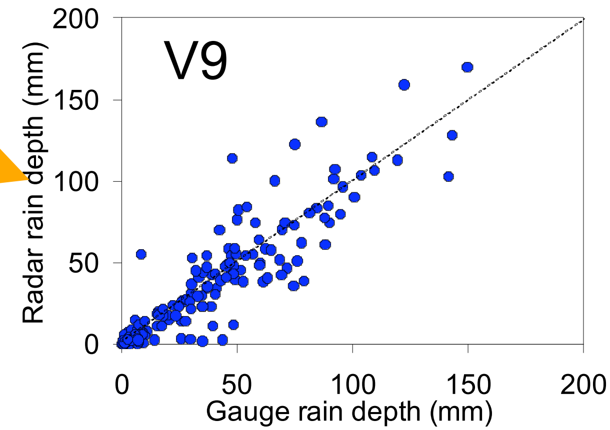
Example of application: QPE
Fit for dry validation areas





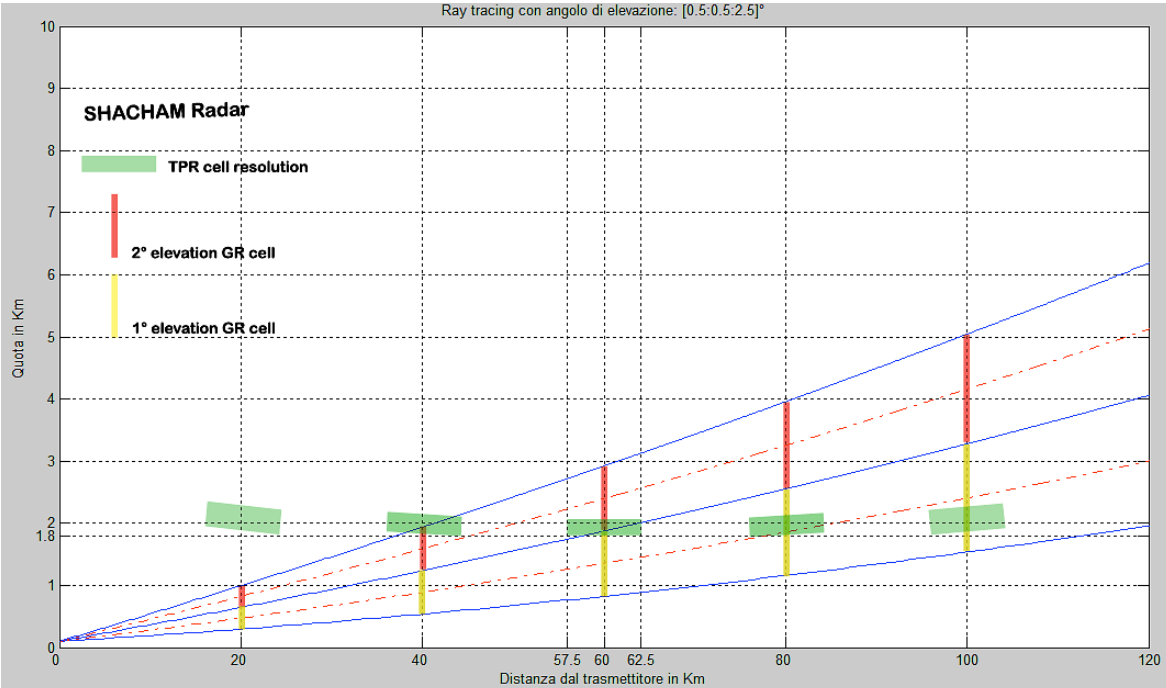






	Bias	FSE
V8	0.97	0.47
V9	0.97	0.30
V10	1.08	0.21
V11	1.00	0.46

Range-adjustment in Israel utilizing TRMM PR



Studying the ratio of the ground-based radar (GR) reflectivity to the TRMM PR (TPR) reflectivity (averaged over rings) as a function of the distance from the GR site

	~1° Elevation	**~2° Elevation**
a_0 (dB)	+1.1±0.4 dB	–0.7±0.4 dB
$\boldsymbol{a_D}$ (dB / decade)	**–4.5**±1.6 (dB / decade)	**–21.3**±2.2 (dB / decade)
Expl. Variance	**58.4%**	**95.0%**

$$10 \cdot \log_{10}\left(\frac{\langle \mathrm{GR} \rangle_{2\pi}}{\langle \mathrm{TPR} \rangle_{2\pi}}\right) = \mathrm{F}_{\mathrm{dB}}$$

$$F_{dB} = a_0 + a_D \cdot Log_{10}\left(\frac{D}{D_0}\right)$$

$$D_0 = 40 \text{ km}$$

Gabella, Joss, Perona and Michaelides, 2006: IEEE Trans. Geosci Rem Sens, 44, pp. 126-133.

April 1-2, 2006 event

Studying the extremes: Hydrometeorological investigation of a flood-causing rainstorm over Israel (Morin et al. 2007)

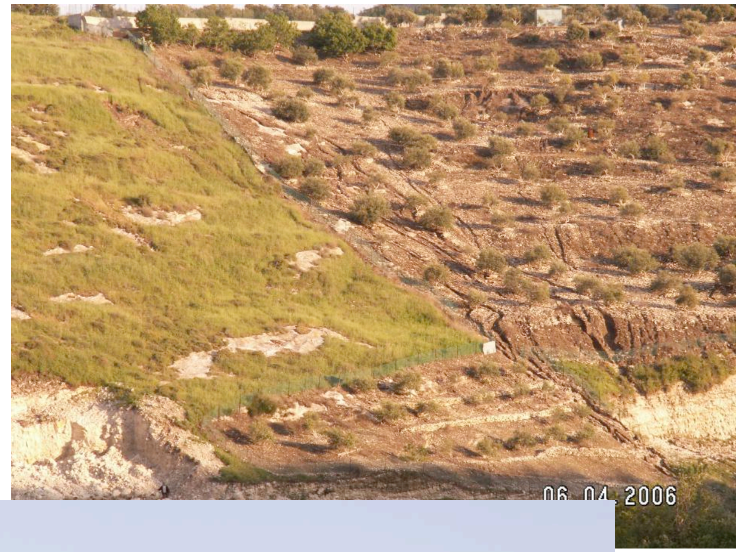
Flash floods in Wadi Ara region

Torrential rain, long lasting thunderstorms over Jerusalem region

Flash floods in the northern Dead-sea region

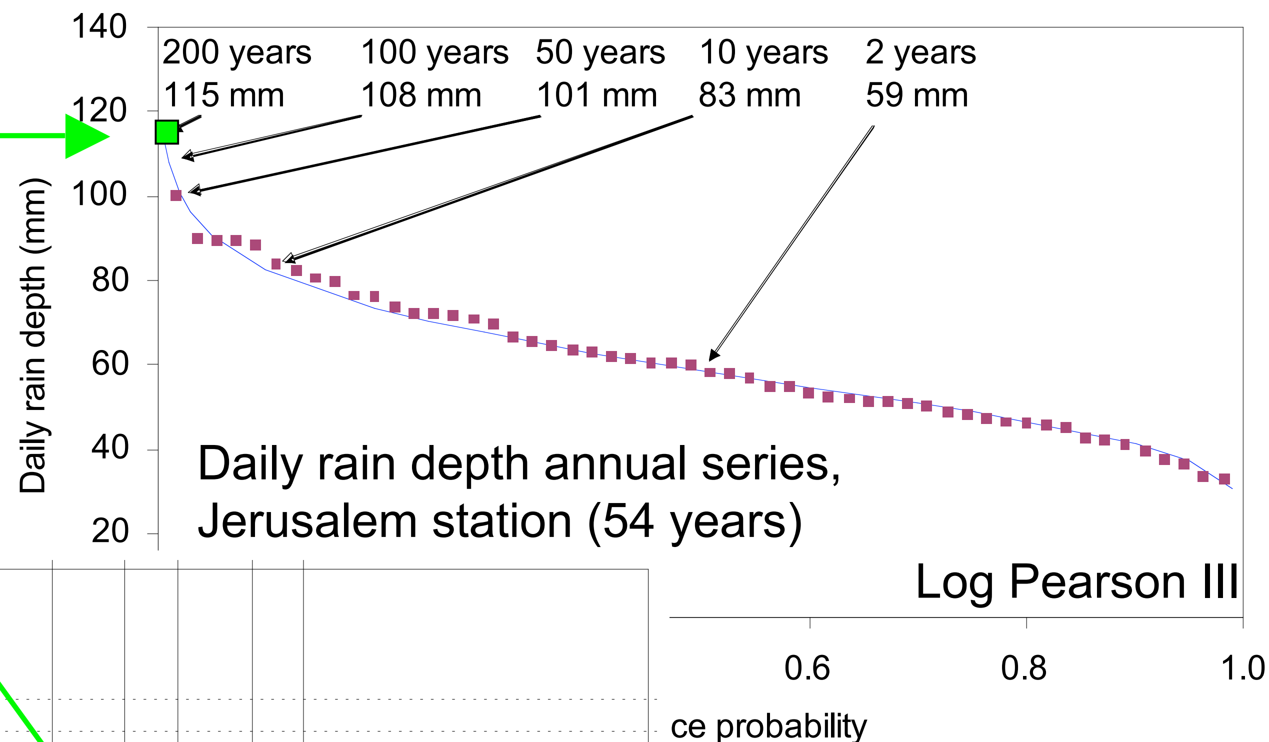
Geomorphologic impact

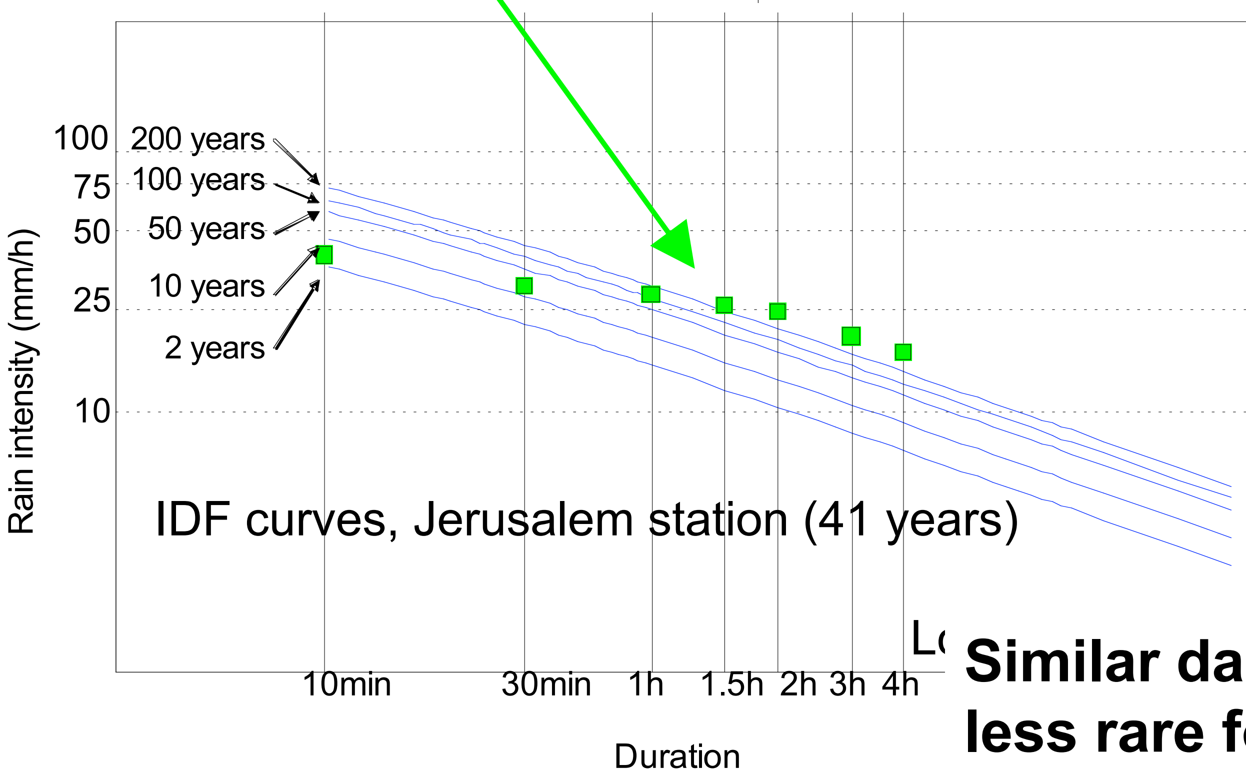
- Severe channel scouring up to 3 m deep
- Numerous of landslides on steep natural slopes
- Soil erosion especially on cultivated fields



Extremeness of rain intensity and depth

Jerusalem data, April 2006 event





Jerusalem: Recurrence intervals of more than 200 years for rain durations of 1 hour to daily!

Similar daily amounts are much less rare for coastal stations

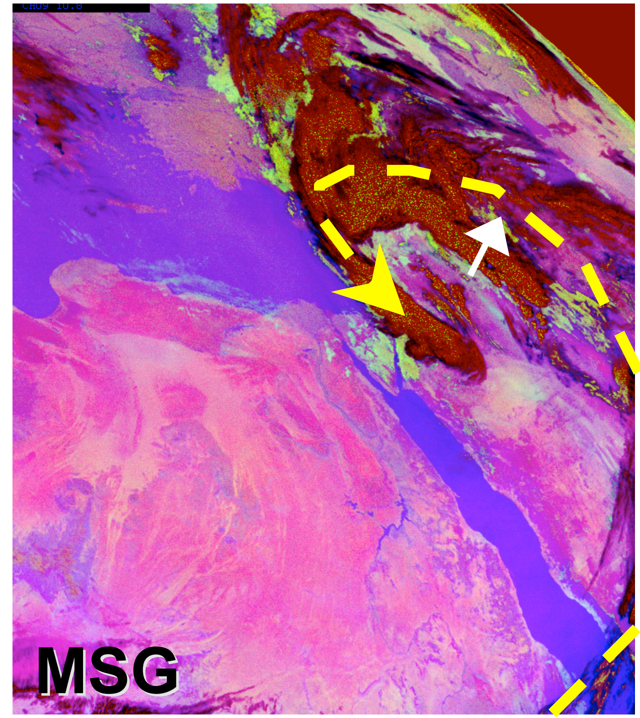
Synoptic conditions

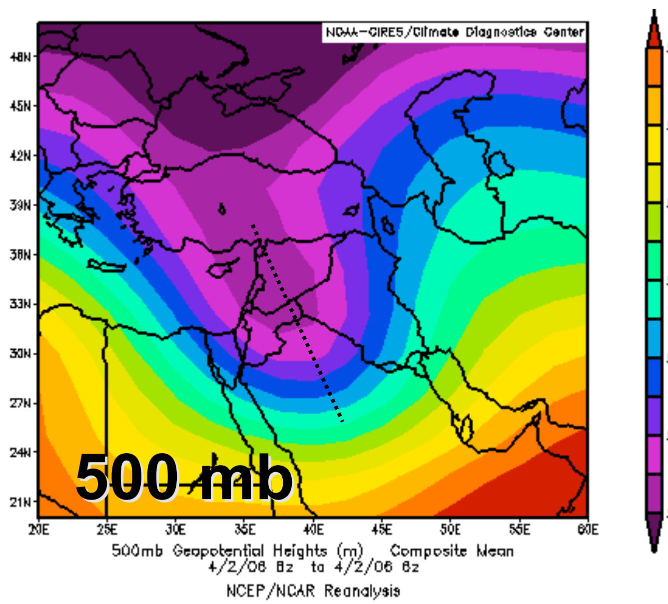
<u>Surface:</u> a deep low pressure located east to Israel.

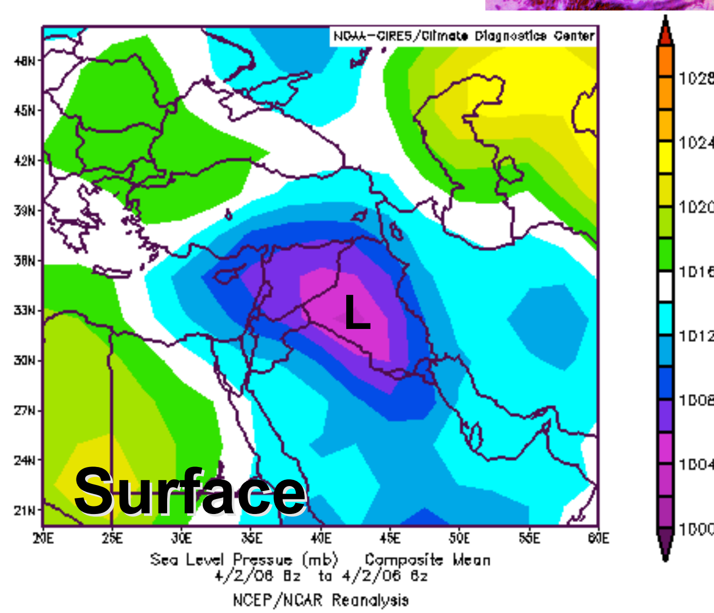
<u>Upper-level:</u> Israel is positioned at the western sector of the deep upper-level trough under inferior conditions (convergence and negative vorticity)

<u>Moisture:</u> tropical source

<u>Moisture track:</u> Eastern Africa → Saudi Arabia → Iraq → Syria → Israel





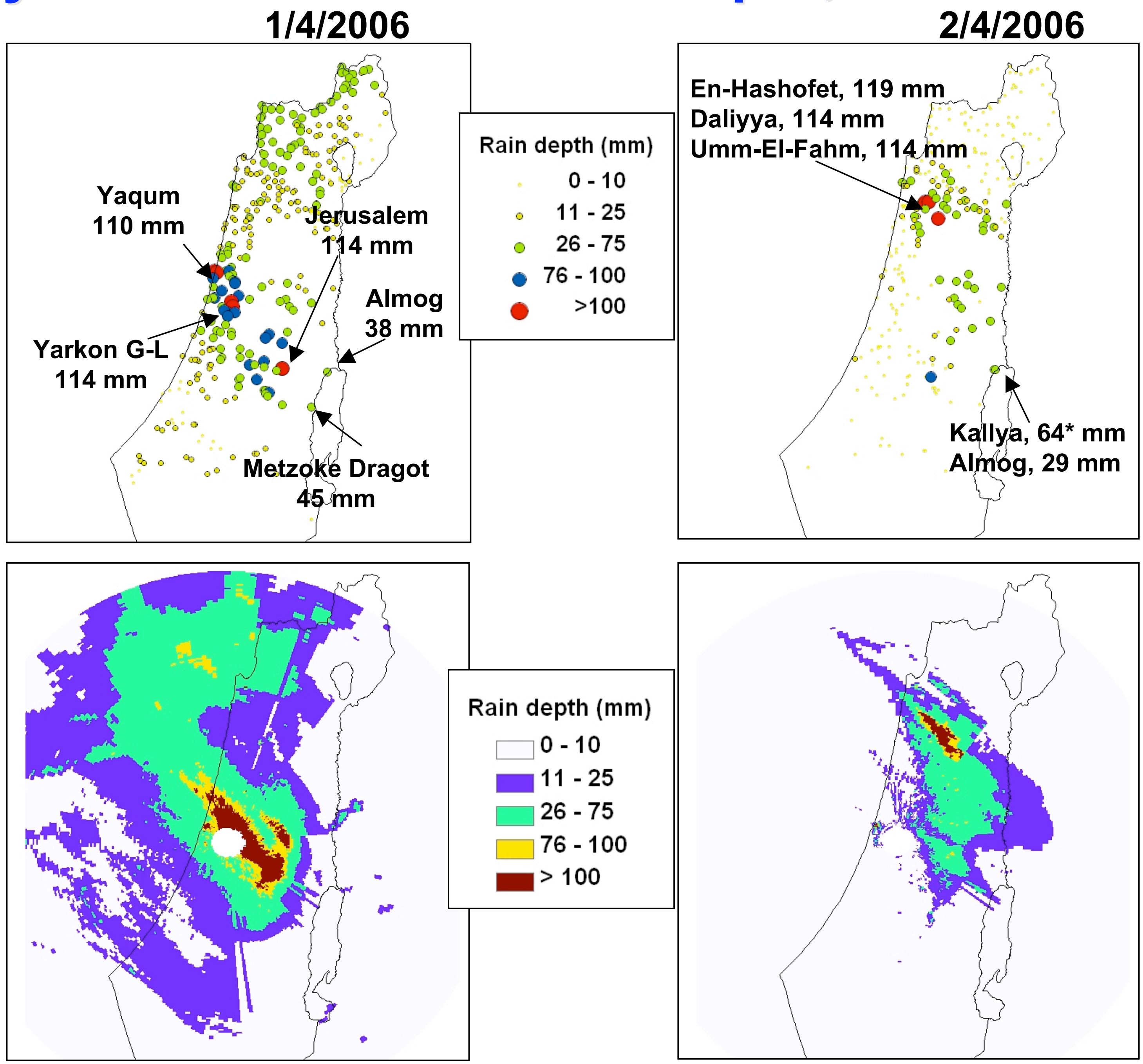


Early morning
April 2, 2006

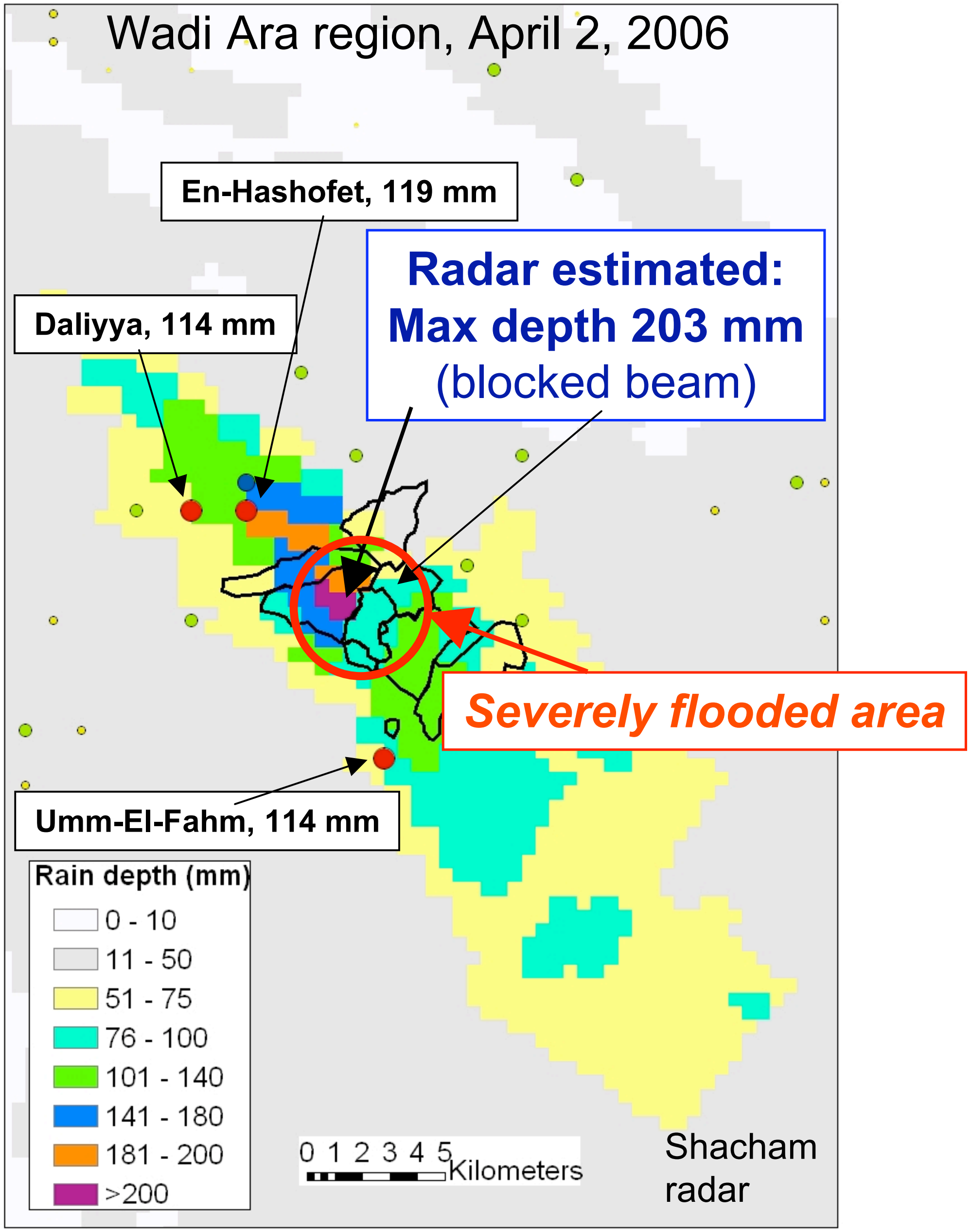
Daily rainfall over Israel: 1-2 April, 2006

Rain gauge
(IMS)

Radar (calibrated)
(Shacham)

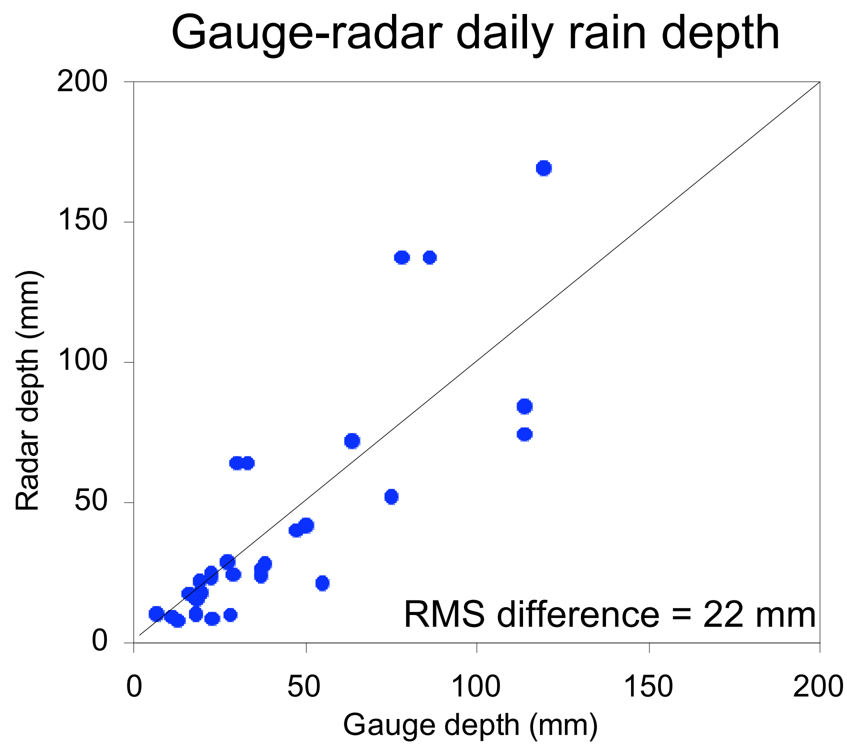


Rain over Wadi Ara region, 2 April, 2006



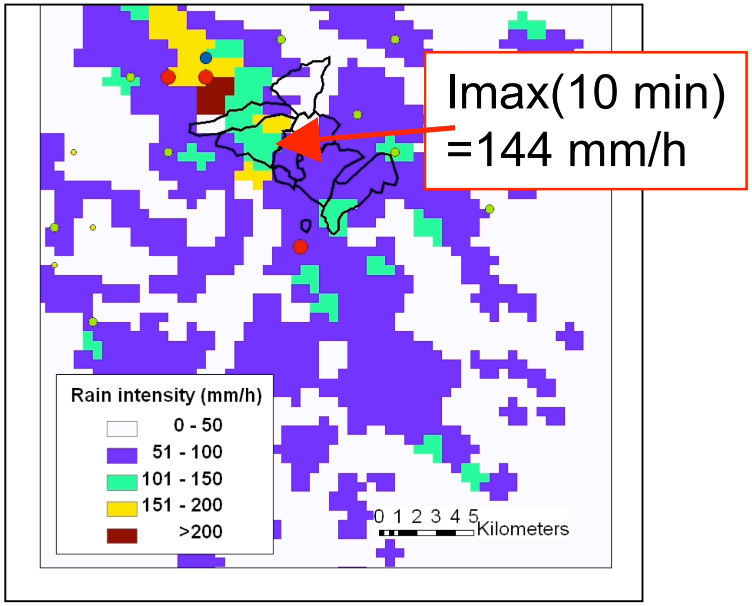
Rainfall estimation from radar adjusted by rain gauge data for the case study

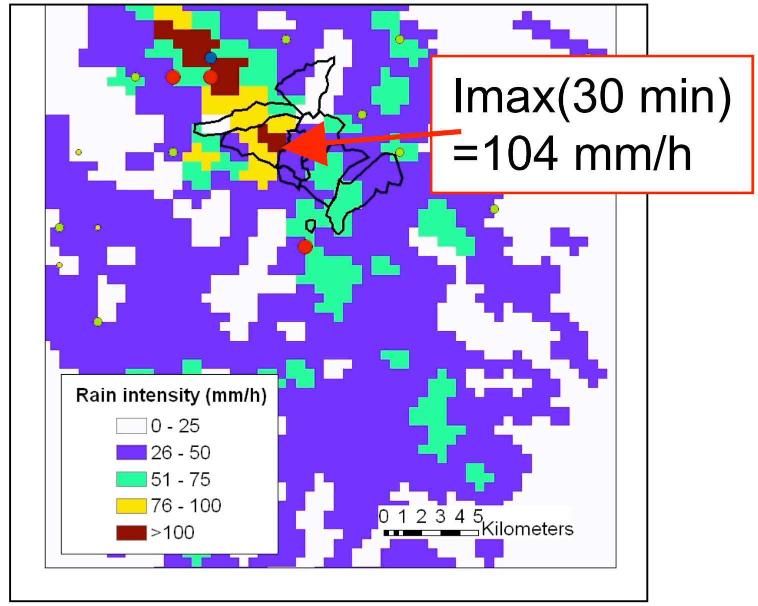
$$Z=170R^{1.5}$$

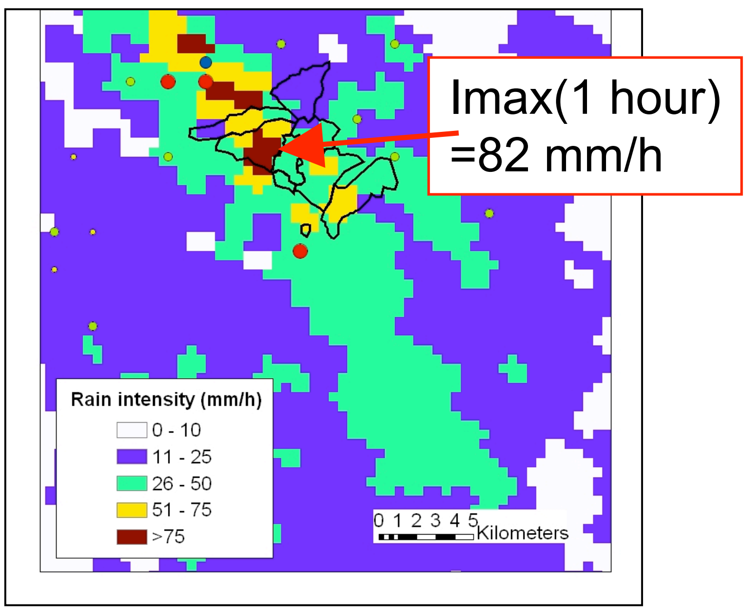


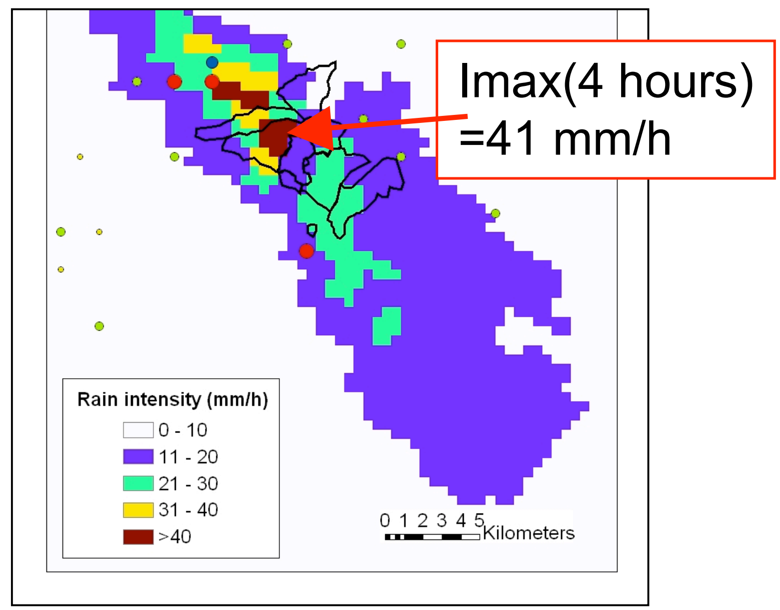
Maximal rain intensities for different durations

Radar-based estimation



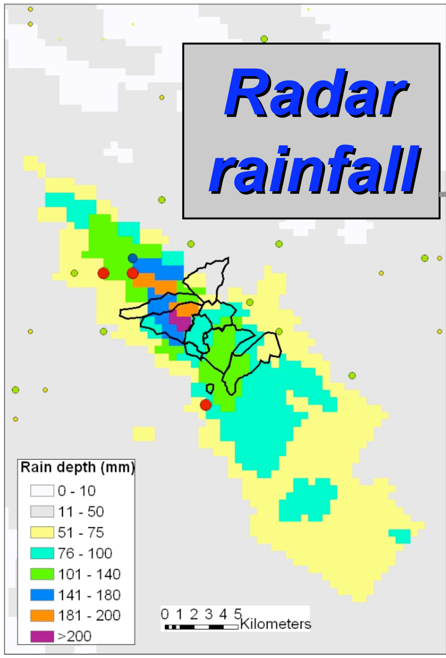






Radar rainfall as input to hydrological model

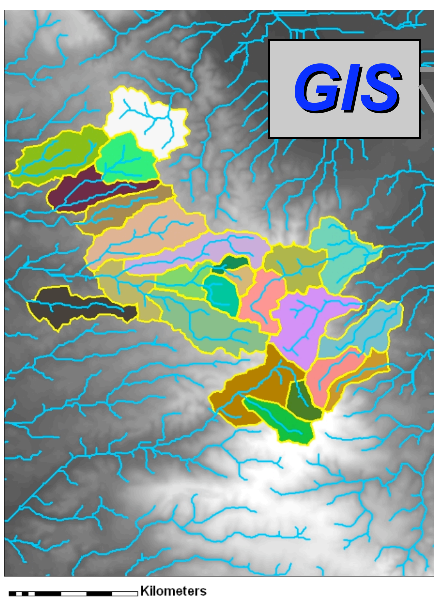
SCS model application



Storm rain depth
Rain excess duration

SCS

Runoff peak discharge (Qp) and runoff volume



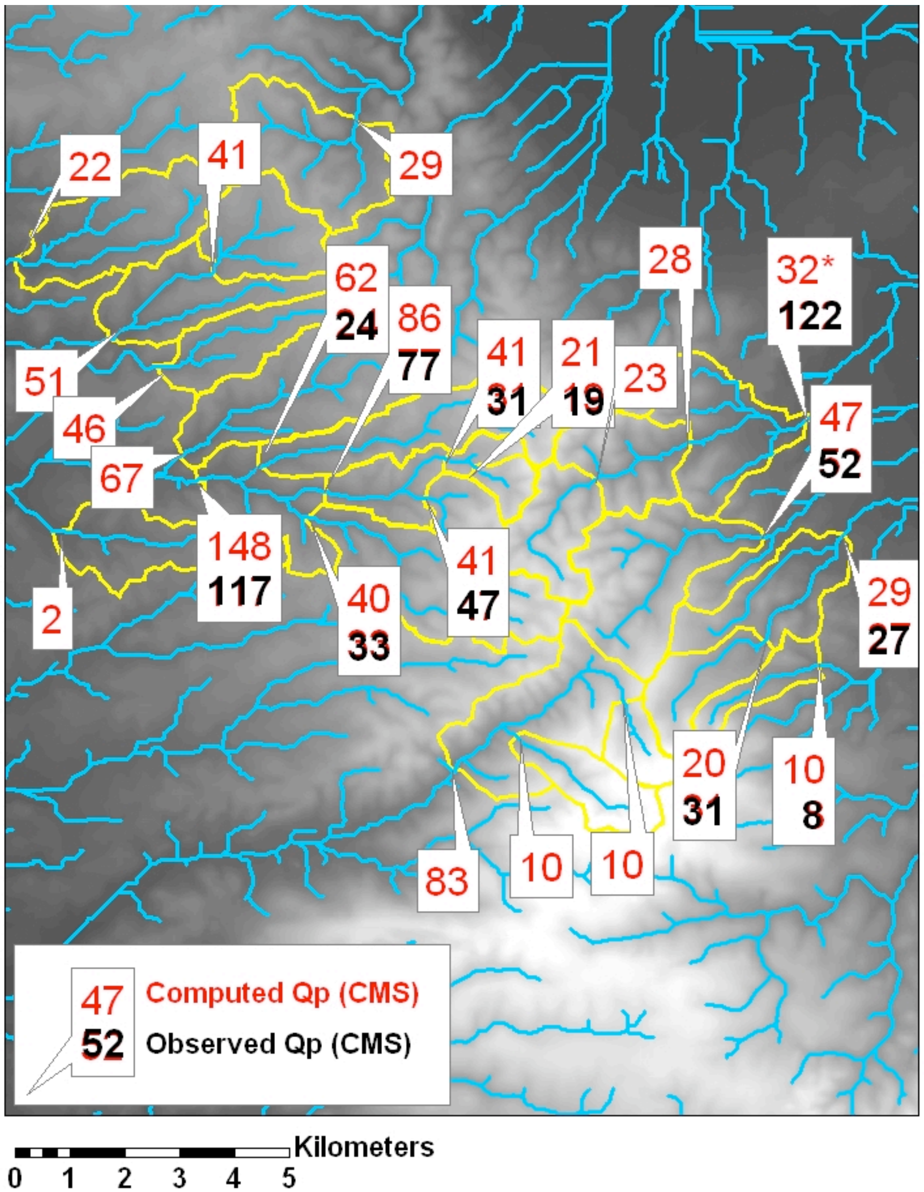
Catchment area
Channel length
Channel gradient

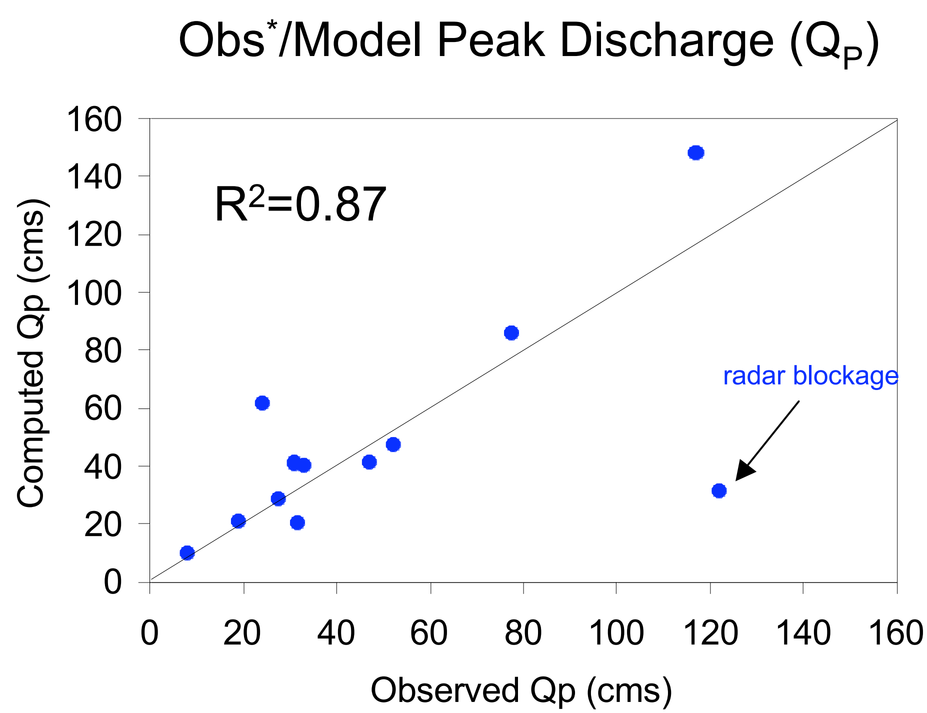
Soil group
Land use
Pre-condition

Published tables

Radar rainfall as input to hydrological model

SCS model application

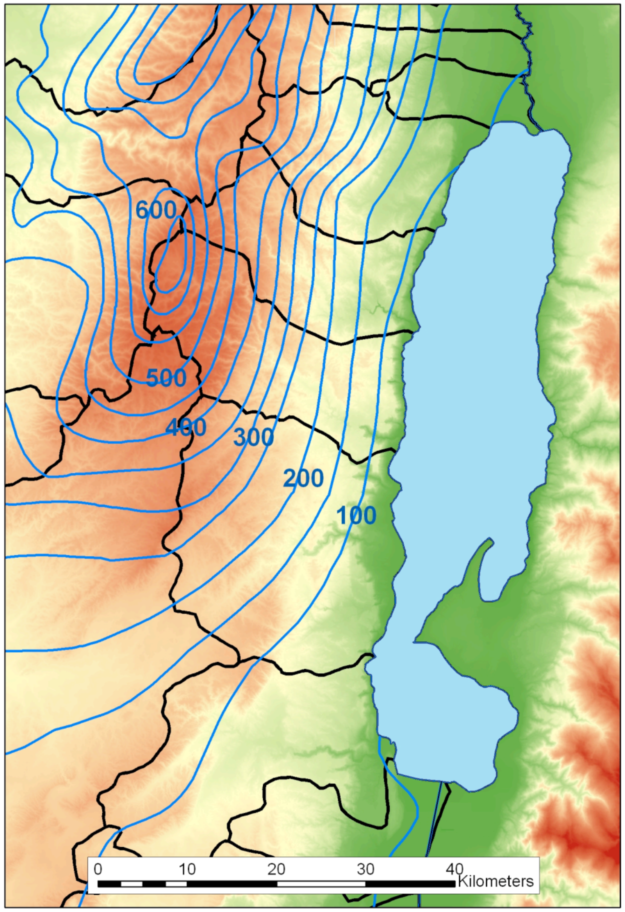


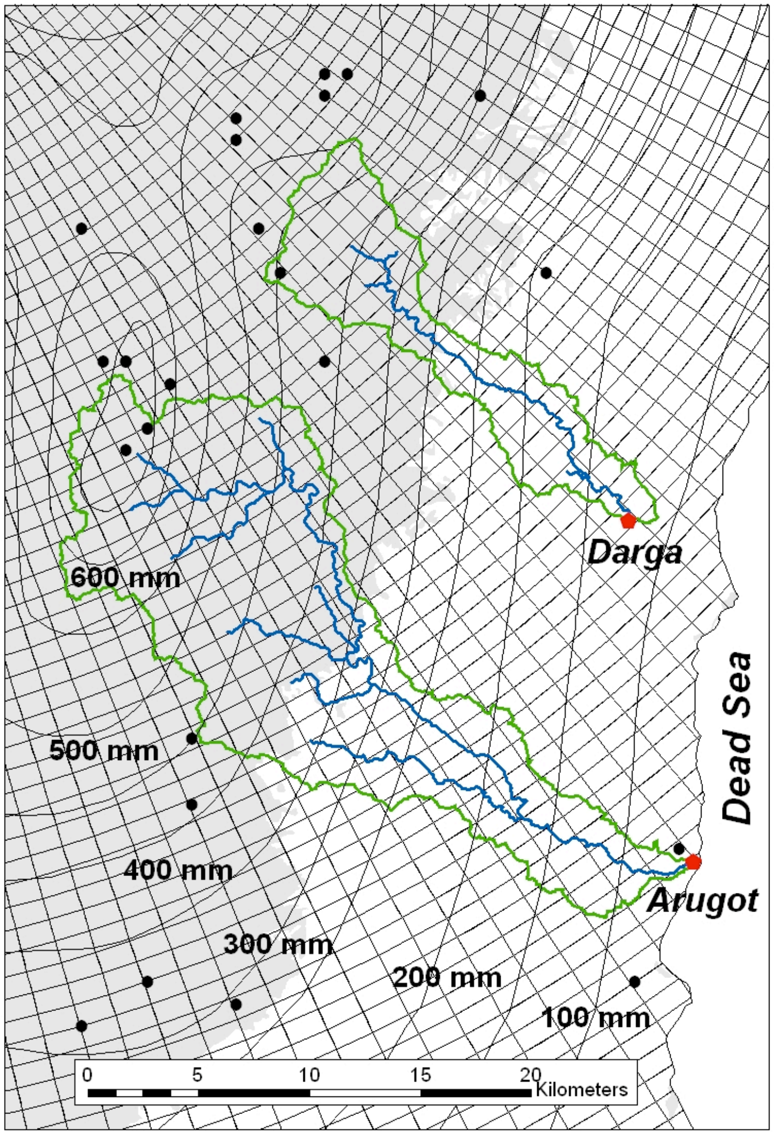


* Peak discharge obs are from high water marks left on channel beds [cms=m^3/s]

Example of application: Flash flood warning model

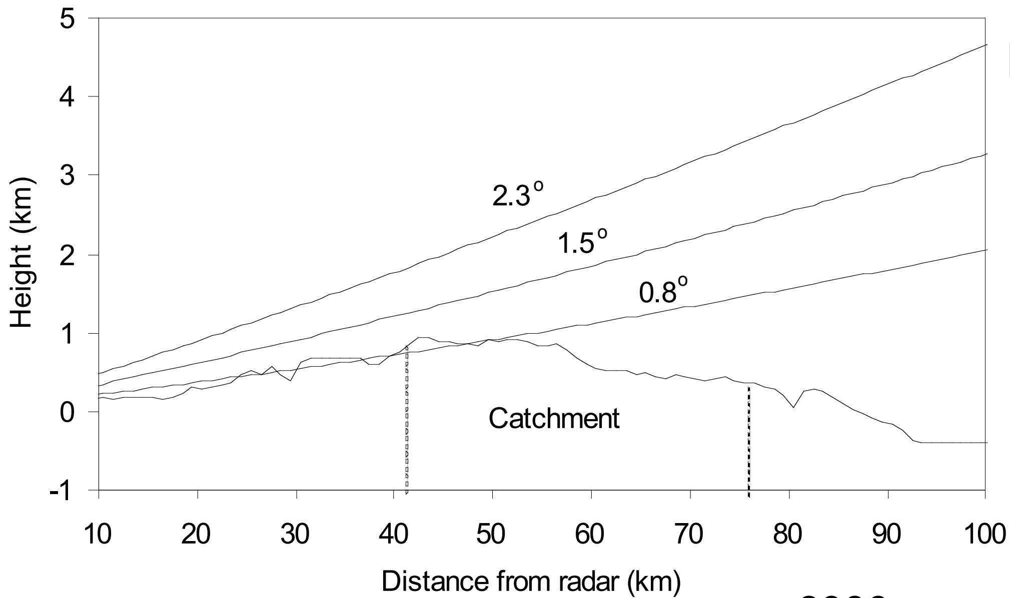
From: Morin, Jacoby, Navon, and Bet-Halachmi, Towards flash flood prediction in the dry Dead Sea region utilizing radar rainfall information, *submitted manuscript*.





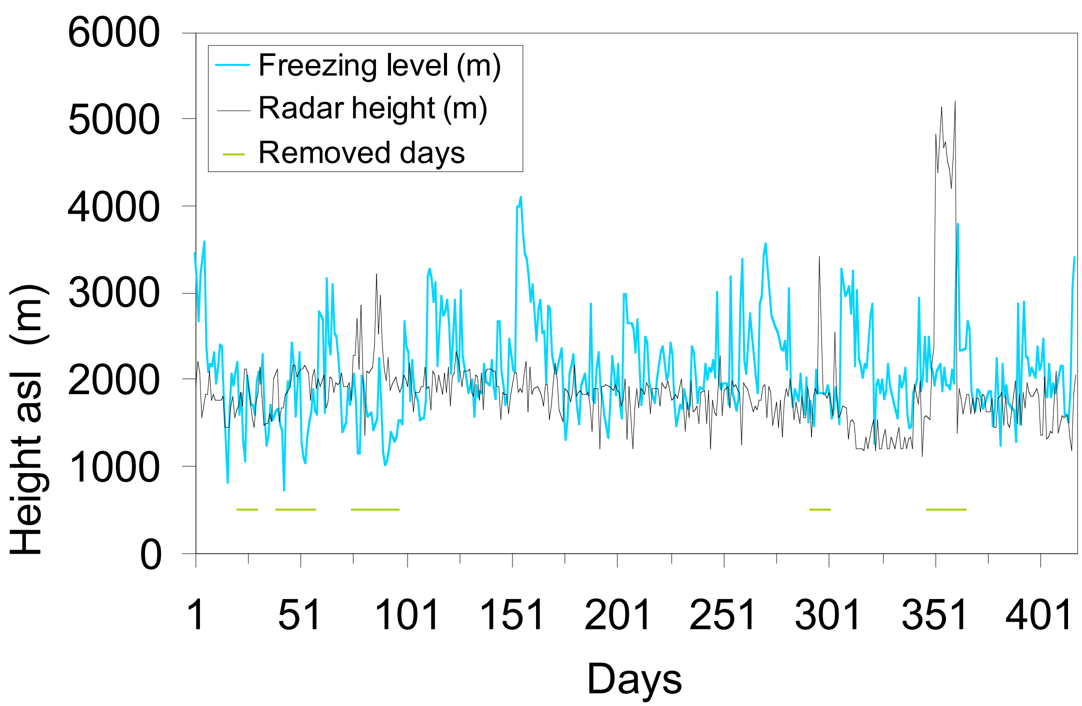
Studied catchments, annual rainfall, radar grid and daily gauges for radar adjustment

Example of application: Flash flood warning model



Radar blockage problem in the region

Days with radar beam height too high relatively to freezing level are removed (45 days in 10 years).
Bulk adjustment method for the QPE in the Dead-Sea (daily adjustment or constant adjustment).



Example of application: Flash flood warning model

QPE are applied to hydrological model for flash flood warning

Validation results:

Catchment	Period	Rainfall data	Number of rainfall events*	Number of detectable floods	Probability of detection	False alarm rate
Arugot	1995/6-2000/1	Daily adjustment	54	17	0.82	0.19
Darga	1991/2-2000/1	Daily adjustment	95	10	0.70	0.19
Arugot	1995/6-2000/1	Constant adjustment	55	17	0.35	0.16
Darga	1991/2-2000/1	Constant adjustment	115	10	0.70	0.17

* A rainfall event with mean areal rainfall > 1 mm

Photos from May 12, 2007 flash flood

ארבעה הרוגים בשיטפון בדרום

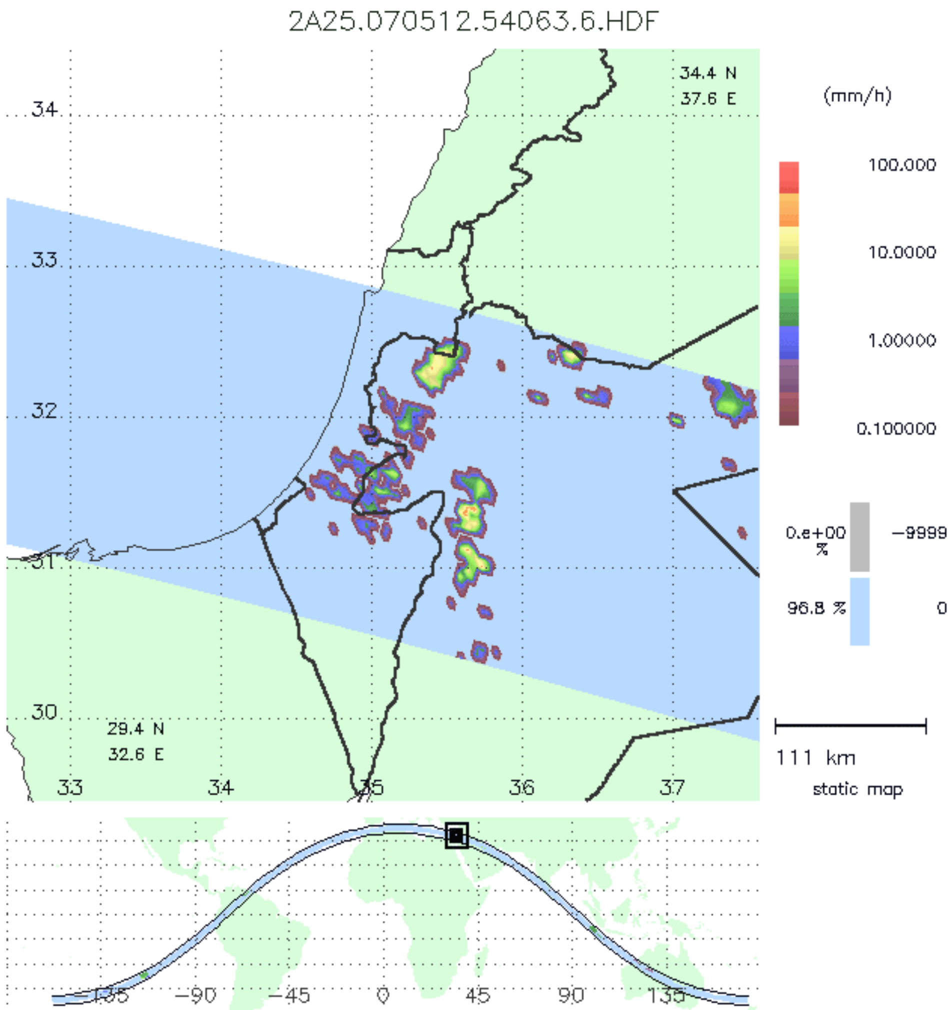
קבוצת מטיילים בנחל קומראן בים המלח נתקעה בנחל בעקבות השיטפונות באזור ו-4 מהם נהרגו • 14 מטיילים חולצו ללא פגע מנחל חצצון לאחר שנתקעו באיזור

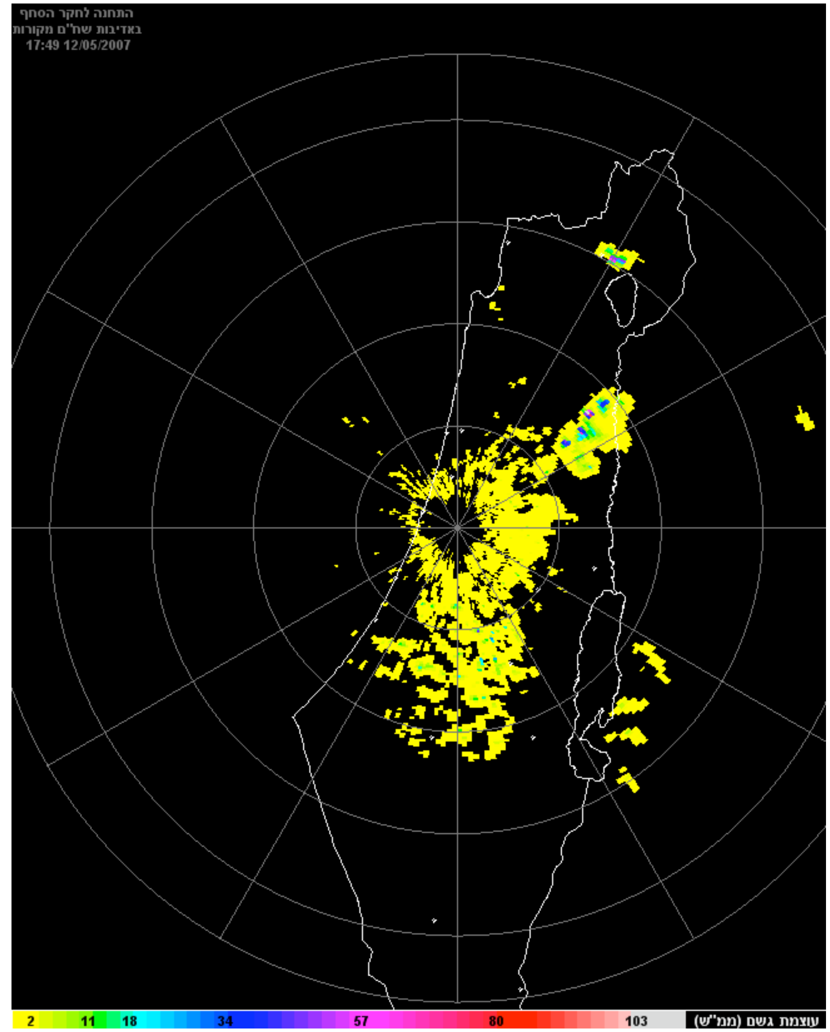
מאת: **מוטי אקסמיט** | | Nfc.co.il

ארבעה מטיילים נהרגו (יום שבת, 12.5.07) בשטפונות באזור ים המלח. הארבעה היו חלק מקבוצה בת 11 מטיילים שנתקעה בנחל קומראן, עקב השיטפונות.

קבוצת המטיילים גלשה ממצוקי נחל קומראן באמצעות סנפלינג למרות האזהרות כי במקום צפויים להיות שיטפונות בעקבות מזג האוויר הגשום.

TRMM flies over Israel
May 12, 2007 @ 14:49 UT



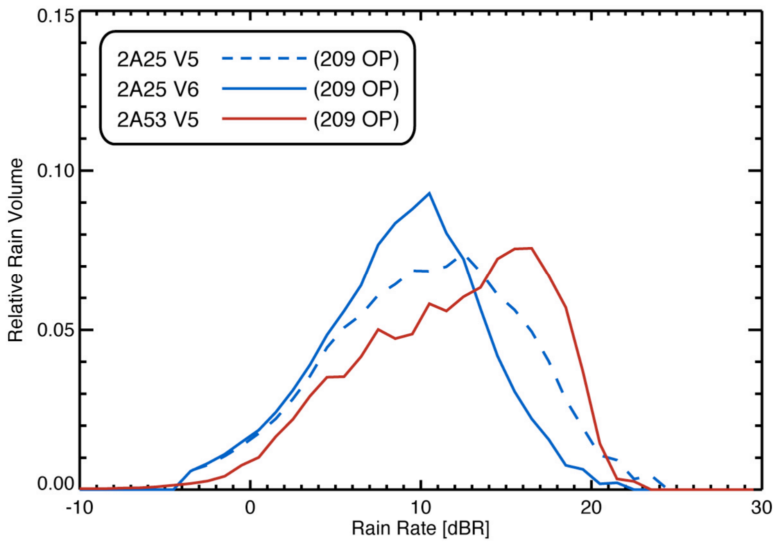


Destructive flash flood in Qumeran catchment (Dead Sea) – 4 people were killed!
Flash floods also occurred in other locations of Israel and Jordan

Near Future Plans:

Comparing TRMM PR and Israel ground radar's Z & R

Comparing pdfs of rain rates from satellite and ground radar observations using same or similar methods being used in other location (e.g., Florida TRMM GV site , NOAA Q2 data)



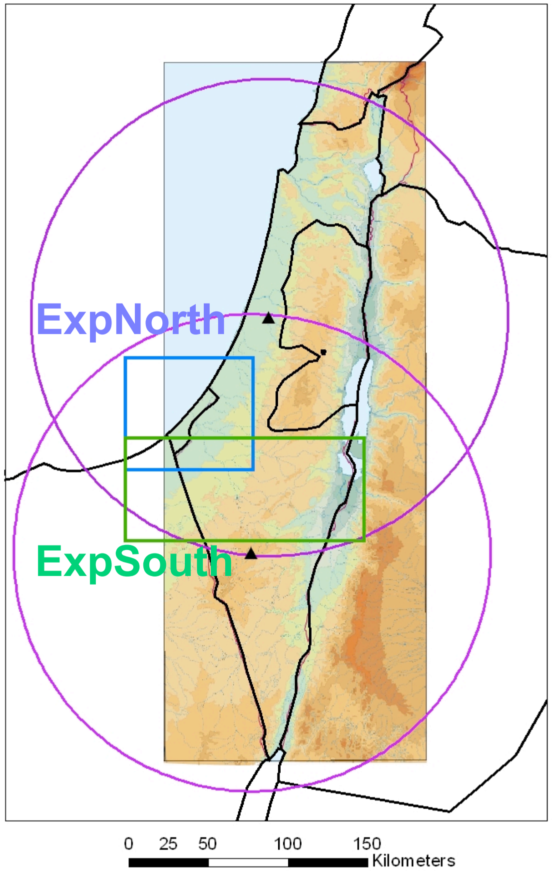
Systematic shifts in precipitation pdf will have significant impact on surface runoff production

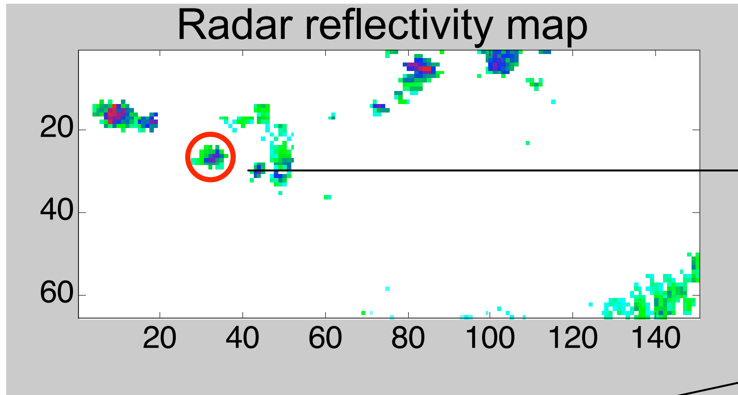
Are these TRMM PR curves represent the general case?

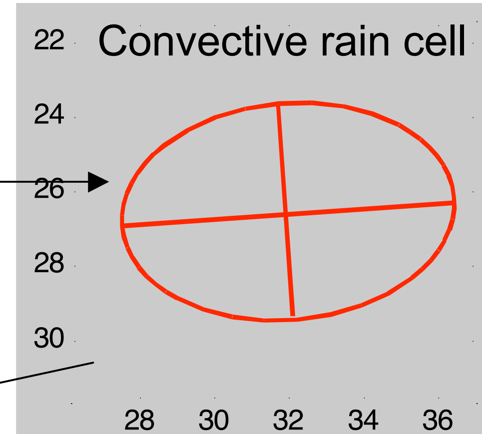
If such comparisons can take place in other parts of the world it will be great…

Example of application: Studying convective rain structures

From: Karklinsky and Morin, Spatial characteristics of radar-derived convective rain cells over Southern Israel. *Meteorol. Z.*, 2006.

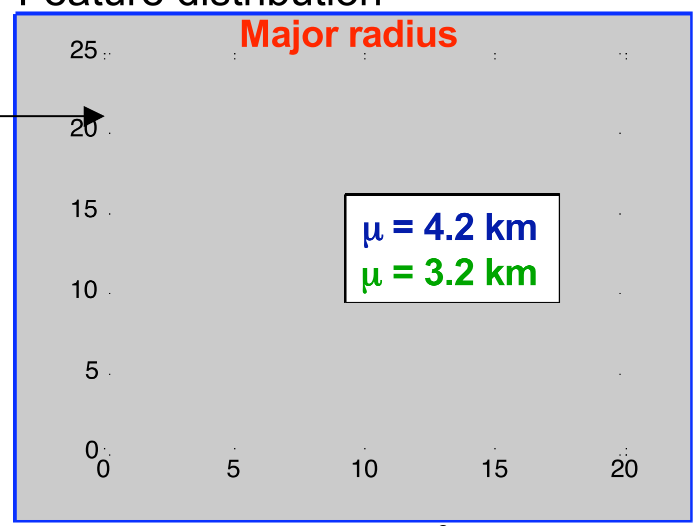






Cell features
Area: 36.3 km²
Orientation: 4.5
Major radius: 4.3 km
Minor radius: 2.9 km
Ellipticity: 0.67
Center X: 32.2
CenterY: 26.6
Max ref: 32 dbz
Max R: 10 mm/h
Integral: 68.2 mm/hxkm²

Feature distribution



Analysis of more than 10^6 rain cells

Characteristics of convective rain cells in southern Israel were studied based on analysis of the Shacham and the Negev radars (~100,000 radar maps).

Potential contribution of Israel to GPM ground validation

- Dense daily (~460) and intensity (~65) gauge networks
- Variability of climates: Mediterranean, semi-arid, arid, hyper-arid
- Variability of ground elevations (Ein-Gedi station is the lowest rain gauge in the world!)
- Flash-flood data provide validation for regions with high rain amounts/intensities that are often missed by gauge networks
- Rainfall data from calibrated ground radars
- Convective storm structures from ground radar to compare with structure from satellite

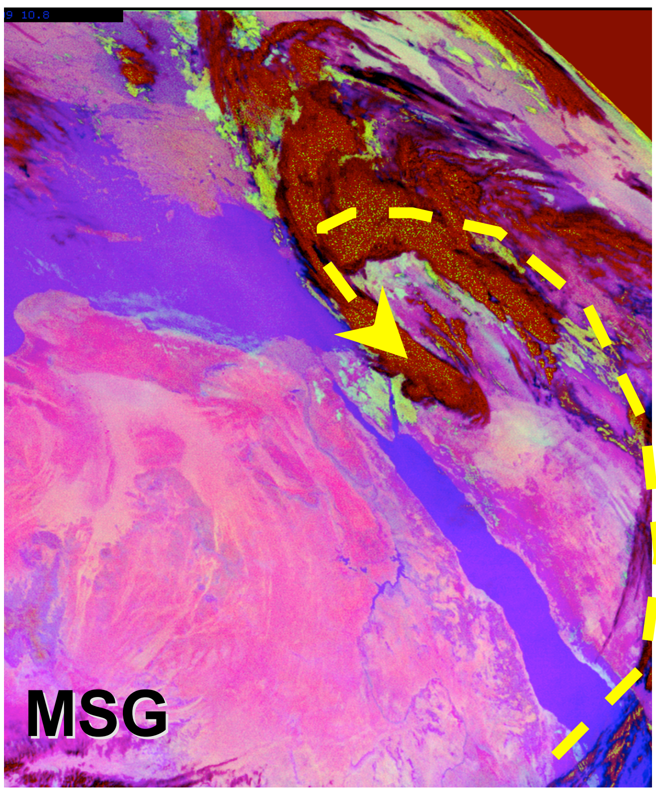
Potential contribution of GPM to Israel

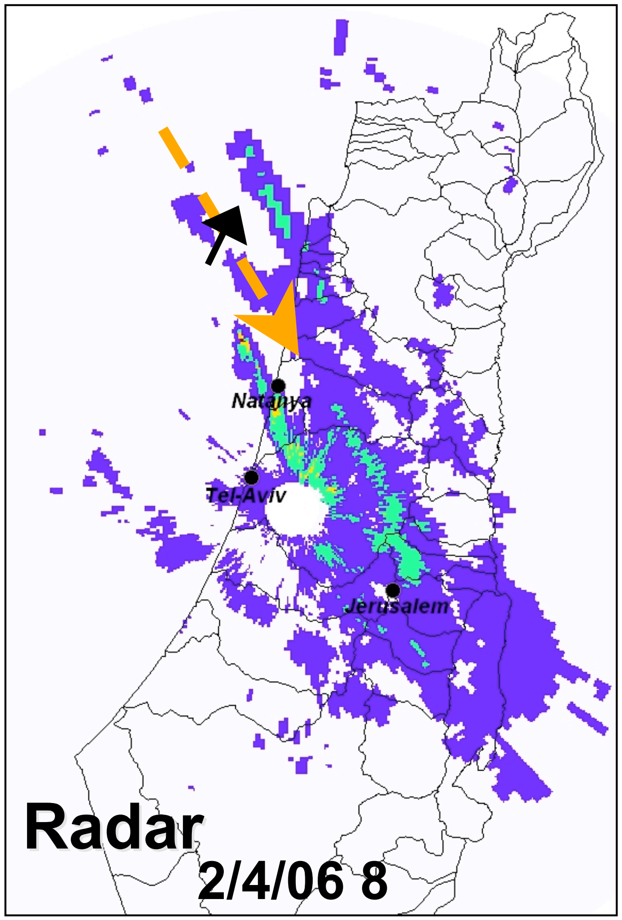
- Real-time satellite observations of precipitation over Eastern Mediterranean Sea
- Data over land in areas not seen well by gauges/radars (eastern and southern parts of Israel)
- Stable reflectivity data for radar internal calibration
- Vertical reflectivity profiles to correct radar data
- Probability distribution functions of reflectivity
- Information on convective storm structures

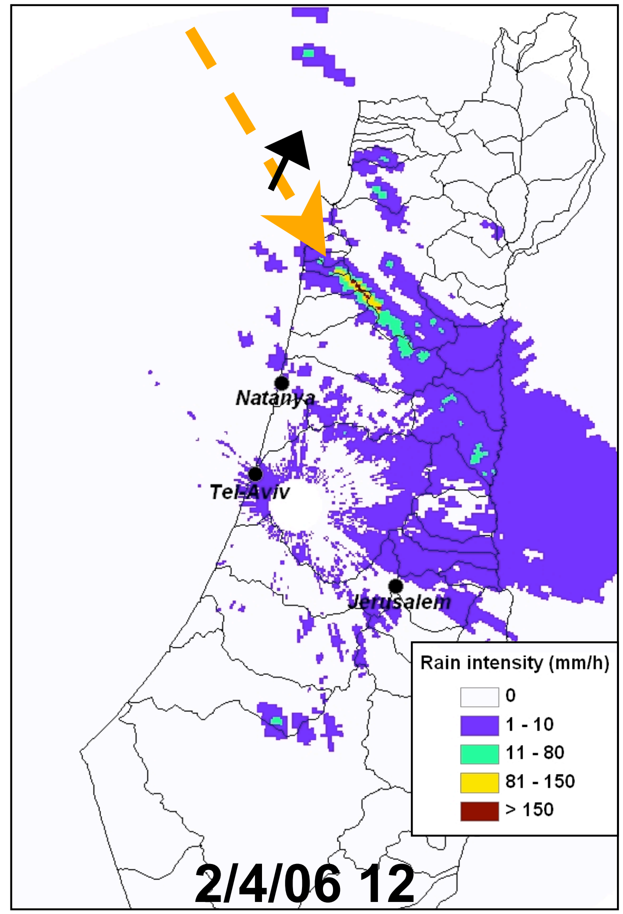
Backup slides

Synoptic conditions

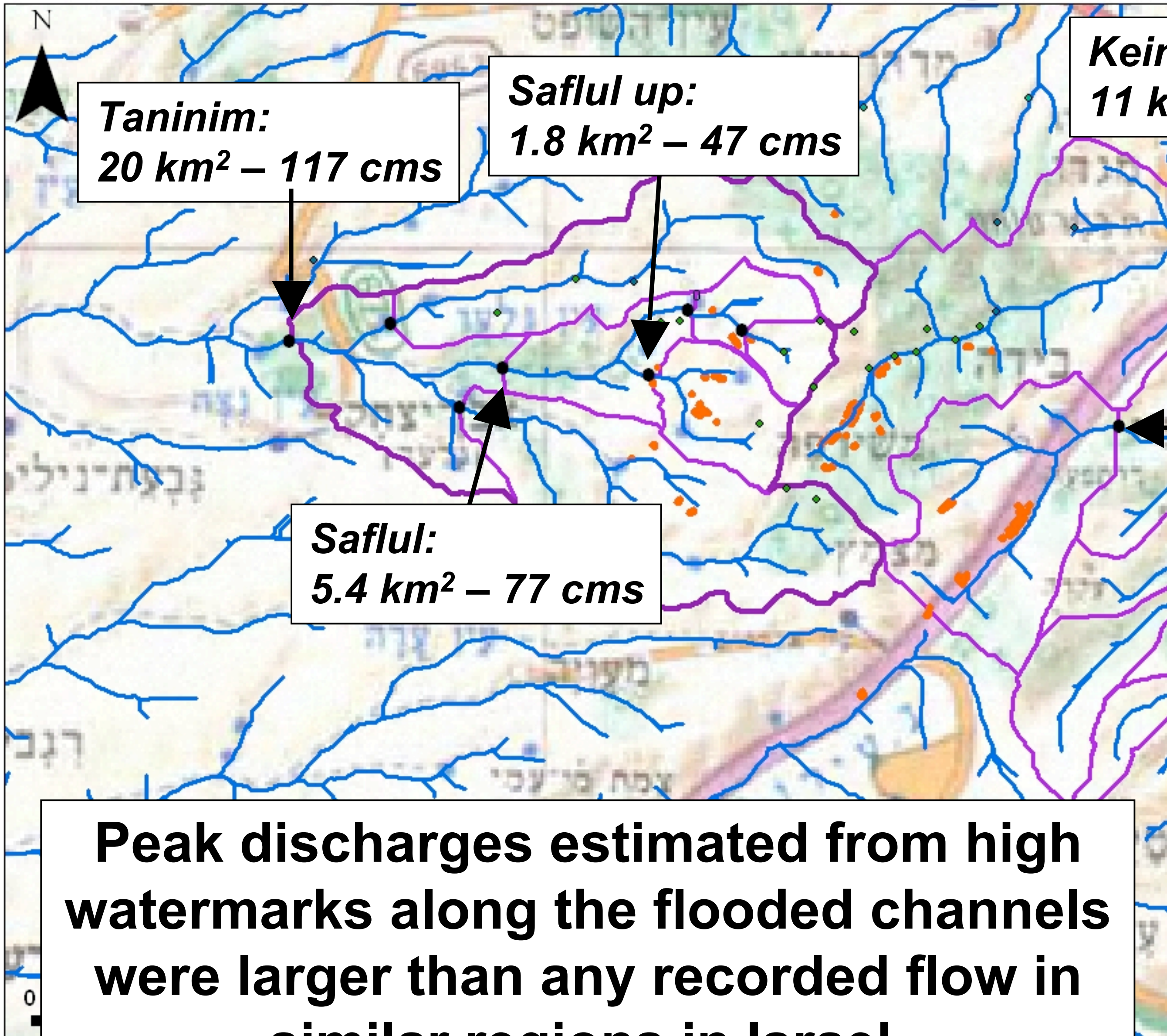
- Storm penetration: from northwest to southeast
- Short track over the Mediterranean sea
- Narrow band of rain cells that move in direction of the band axis ("train effect")
- High rain amounts/intensities over limited area



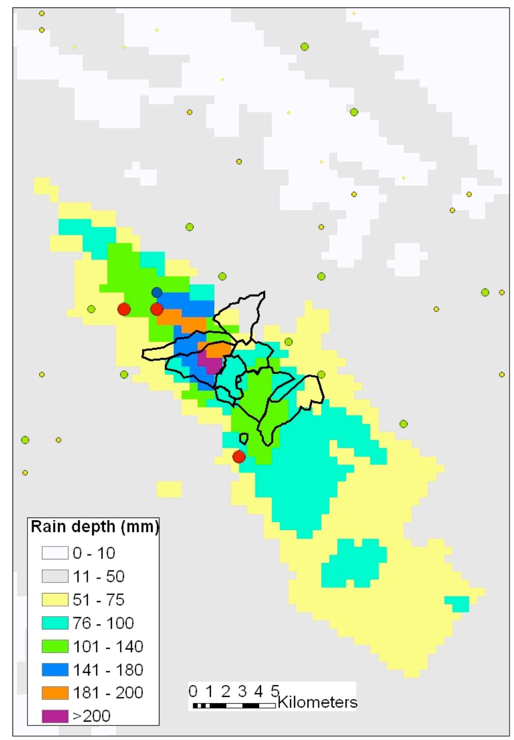




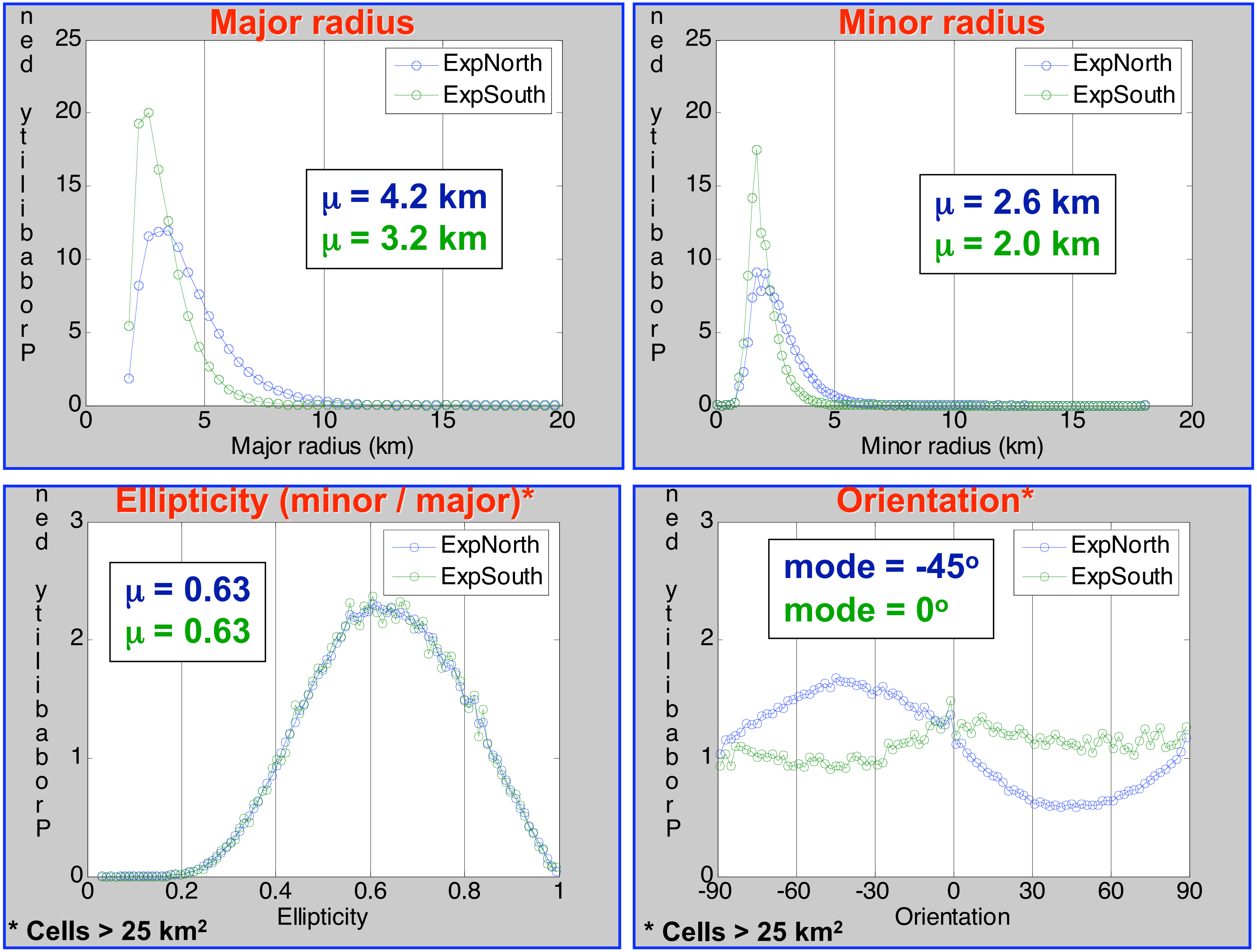
Flash floods in Wadi Ara region, 2 April, 2006



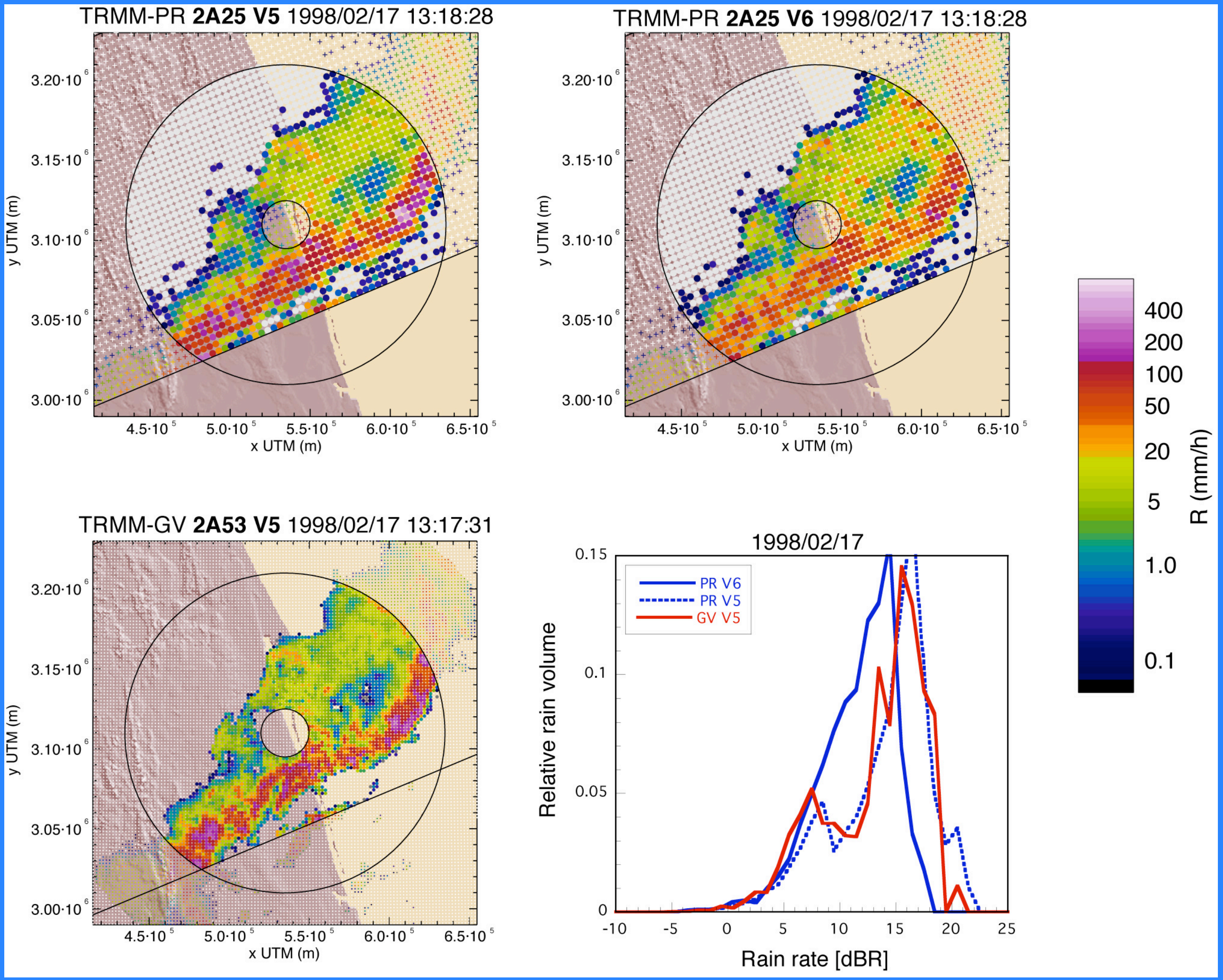
Peak discharges estimated from high watermarks along the flooded channels were larger than any recorded flow in similar regions in Israel.



Example of application: Studying convective rain structures



TRMM PR-WSR88D (GV) Rain Rate Comparison



Comparison of rain rate fields and their associated pdfs for the February 17, 1998 TRMM overpass over central Fl: PR V5 (upper left), PR V6 (upper right), GV at approximately 1-min before the overpass (lower left) and their corresponding pdfs (lower right). Is PR V5 better than V6 as suggested by the GV estimates? (Amitai et al. 2006, *MZ*)

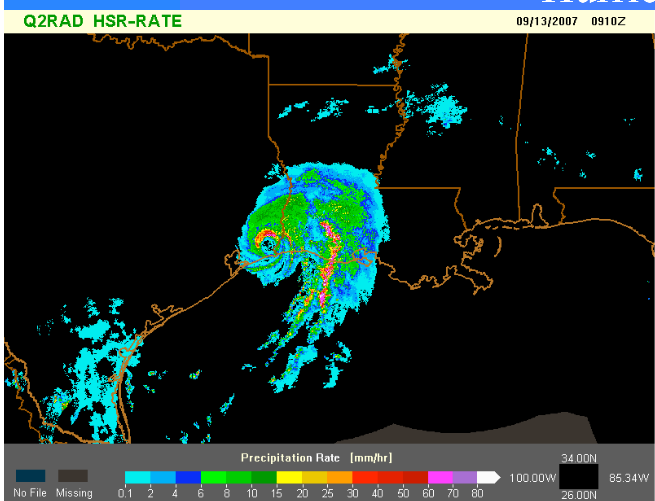
Utilizing the National Network for Statistical Verification of Satellite Rainfall Estimates

PI: Eyal Amitai (George Mason University)
U.S. Collaborators: Steven Vasiloff (NOAA/NSSL), David Kitzmiller (NOAA/OHD), Robert Meneghini (NASA/GSFC)
Foreign Collaborators: Daniel Sempere-Torres (UPC, Spain), Xavier Llort (UPC, Spain)

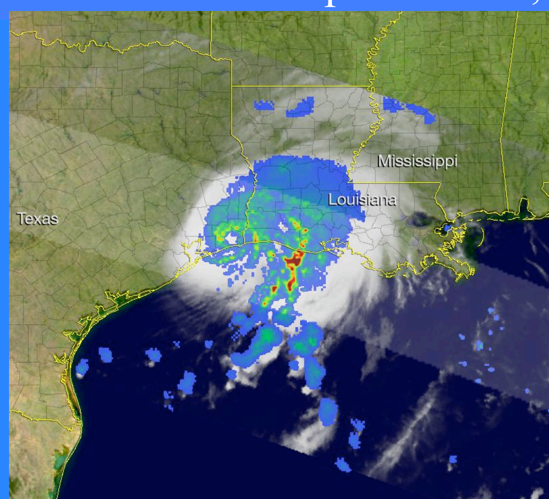
★ **Evaluating the potential use of existing U.S. national network of radars and rain gauges for statistical verification of TRMM and future GPM estimates**

★ **Identifying and resolving significant discrepancies between the U.S. national network and satellite estimates: When, Where and Why**

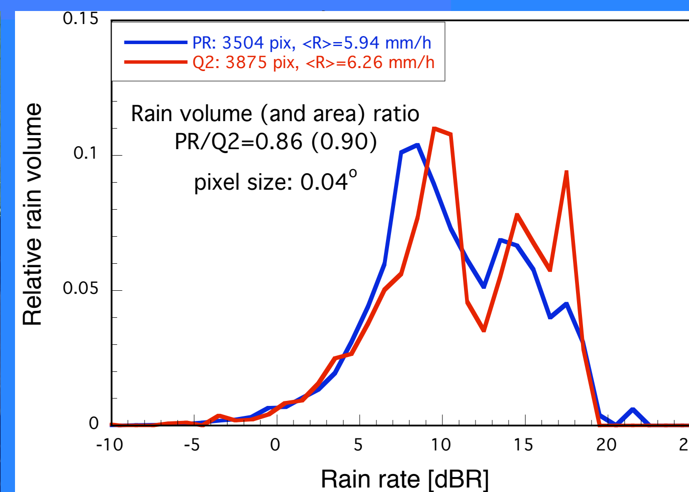
Hurricane Humberto: September 13, 2007



NOAA Q2 09:10Z



TRMM PR 09:10Z

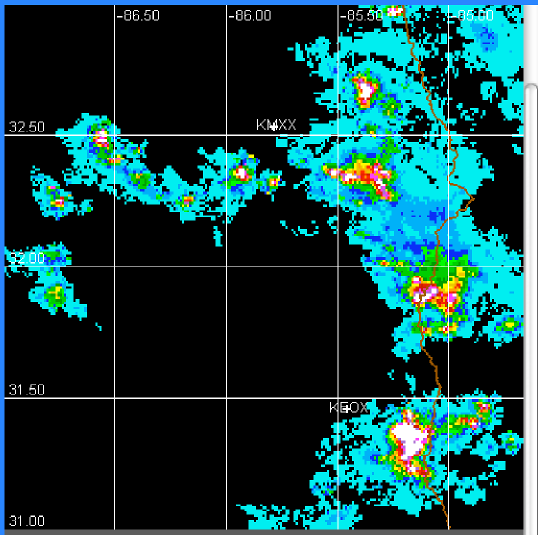


NASA Grant NNX07AK47G (2007-2010)

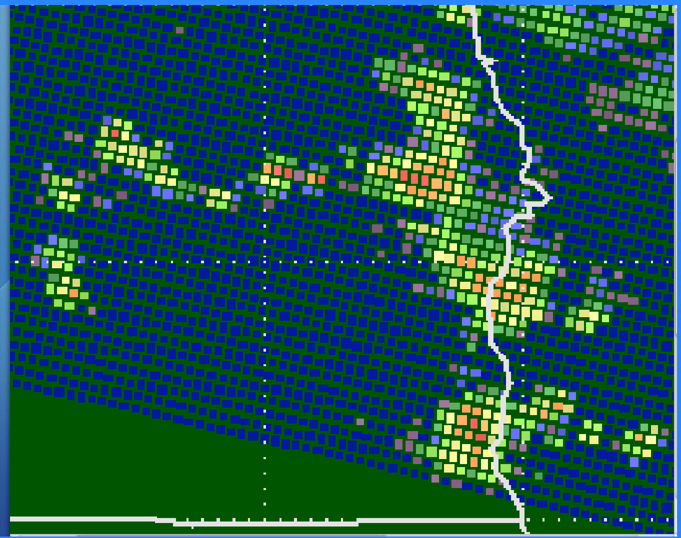
Utilizing the National Network for Statistical Verification of Satellite Rainfall Estimates

May 12, 2007 @ 22:30 UT

NOAA Q2

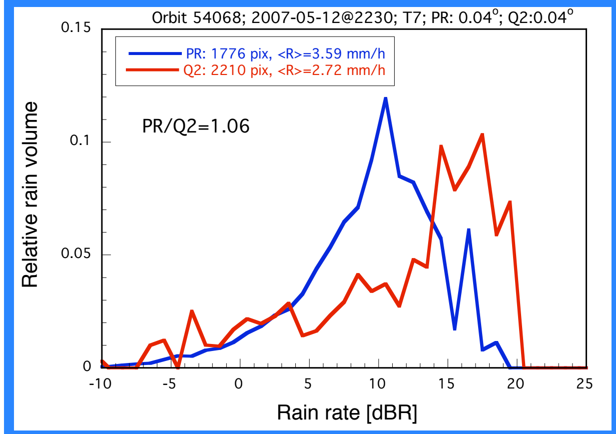


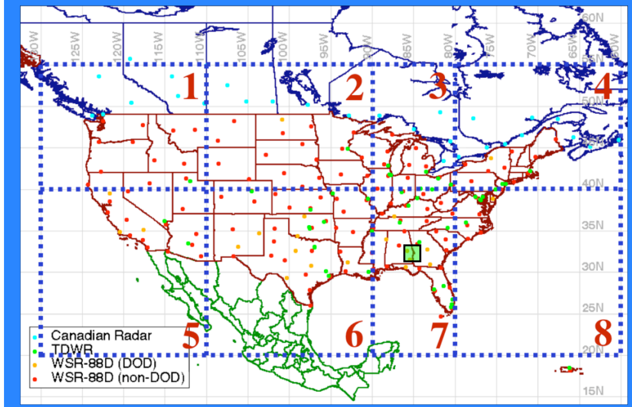
TRMM PR



Comparison of NSSL Q2 and TRMM PR near surface rain rates over a portion of Tile 7 (green square in lower right panel).

All PR and Q2 rainy values within the PR swath regardless whether both observed rain at the same pixel are used to generate the pdfs. Data are matched-up into a common grid with 0.04º resolution.





Recent effort to evaluate TRMM PR instantaneous rain rate estimates by comparing pdfs reveals large discrepancies in the rain rate distributions (Amitai et al. 2006)

NASA Grant NNX07AK47G (2007-2010)